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Feasibility Study

Port Quendall Project

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RETEC Project No.: 3-2438-612

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November 21, 1997

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Executive Summary

Introduction

This document presents a focused draft Feasibility Study (FS) prepared by RETEC on behalf of The Port Quendall Company (PQC) in support of PQC's due diligence. The report is subject to the disclaimer provisions found in Section 1.3. PQC is evaluating the feasibility of purchasing four adjoining parcels located along the eastern shores of Lake Washington. Two of these parcels, J. H. Baxter and Quendall Terminal, are extensively contaminated with coal tar and wood preserving compounds due to historical industrial operations on the site. This FS focuses on those two sites.

There has been extensive interaction with the resource agencies and the sellers in the preparation of this draft FS. Additional site investigations will be required by the Department of Ecology before approving a final cleanup plan for the site. However, sufficient information exists at this time to define the range of feasible alternatives for these two sites.

In developing this FS, RETEC summarized existing information on the sites, collected additional sediment data, completed a comprehensive groundwater model for the site, initiated soil and groundwater treatability studies and screened a number of remedial technologies or presumptive remedies which meet the requirements of the Model Toxics Control Act (MTCA).

Site Characteristics

The site is located on the former delta of May and Gypsy Creeks. The shoreline of Lake Washington and the location of these former channels has changed significantly over time. In addition, a substantial amount of filling has occurred over the past 80 years. The subsurface geology is highly heterogeneous, but can be generally described as comprised of three zones: an upper fill zone, an intermediate silty peat zone and a lower sand zone. Depth to bedrock varies greatly but is generally believed to be greater than 150 feet along the current Lake Washington shoreline.

Groundwater is found at depths of less than 10 feet below ground surface on the uplands, and discharges towards Lake Washington. Groundwater velocities are in the range of 0.05 feet per day in the silty peat zone and 0.5 feet per day in the lower sand unit. The lake bottom is generally less than 30 feet deep within the Outer Harbor line and is relatively flat.

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Geotechnical studies conducted during this study indicate that the soils are compressible and subject to liquefaction. Any substantial buildings on the site will need to be supported by piles to depths greater than 90 feet.

Nature and Extent of Contamination

The principal constituents of concern on the Quendall site are polynuclear aromatic hydrocarbons (PAHs) and benzene, which are associated with the former coal tar refining process. The primary constituents of concern at the Baxter site are PAHs and pentachlorophenol. Sediments are primarily contaminated with PAH. In addition, a large portion of the sediments contain wood waste from former and current in-water log rafting operations.

The available soil, groundwater and sediment data was compared to regulatory screening criteria. In addition, field observations of free phase product were compiled to estimate the extent of free and residual dense non-aqueous phase liquids (DNAPLs) in the subsurface. Over 400,000 cubic yards of soil exceed regulatory screening criteria. Approximately 70,000 cubic yards of soil are considered highly contaminated and contain either free or residual DNAPL.

Approximately 30,000 cubic yards of sediments contain PAH compounds that exceed 100 mg/kg PAH. An additional 50,000 cubic yards of sediments contain wood waste that is greater that 50 percent by volume. Over 100,000 cubic yards of sediments contain measurable wood waste which is less than 50 percent by volume.

Groundwater exceeds applicable surface water criteria over most of the study area. Free phase product has been observed in several wells on the Quendall property.

Remedial Alternatives Analysis

An initial technology screening was conducted to evaluate potential remediation technologies applicable to the site conditions within the context of the proposed property redevelopment. The applicable technologies were combined into a set of five soil alternatives, three groundwater alternatives, four containment wall alternatives and five sediment alternatives and screened for implementability, effectiveness and costs. Following this screening, the remaining alternatives were combined into four comprehensive soil and groundwater alternatives and three comprehensive sediment and containment wall alternatives. Table E-1 summarizes these two basic groupings.

The alternatives were analyzed for compliance with the requirements for remedy selection in the MTCA which include:

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Table E-1 Summary of Media-Specific Remedial Alternatives

Alternative Number	AC - Soil and Groundwater				Alternative Number	BD - Sediment and Containment Wall		
	Treatment	DNAPL Recovery	Cap	Groundwater		Treatment	Mitigation	Containment Wall
AC0	No soil treatment	North Sump Quendall Pond Former May Creek	All areas exceeding Method B criteria	Biosparge and pump-and-treat	BD0			
AC1	Hazardous Waste	North Sump Quendall Pond Former May Creek	Remaining areas exceeding Method B criteria	Biosparge and pump-and-treat	BD1	Remove/Recycle Wood Waste CDF - 2.9 acres Dredge and CDF T-Dock Nearshore Toe Excavate Baxter Cove Grey Zone Natural Recovery	Wetland Replacement Gypsy Creek Realign 2.9 acre CDF mitigation	Nearshore Wall (2.9 acre CDF)
AC2	Nearshore DNAPL	North Sump Former May Creek	Remaining areas exceeding Method B criteria	Biosparge and pump-and-treat	BD2	Remove/Recycle Wood Waste Cap Nearshore Benzene Dredge and Upland Mgmt T-Dock Nearshore Partial Excavate Baxter Cove Grey Zone Enhanced Natural Recovery	Wetland Replacement Gypsy Creek Realign 0.5 acre fill mitigation	Nearshore Wall (0.5 acre cap)
AC3	All DNAPL	North Sump	Remaining areas exceeding Method B criteria	Biosparge	BD3	Remove/Recycle Wood Waste Dredge and Upland Mgmt Grey Zone T-Dock Nearshore to max. 5 feet below mud line Excavate Baxter Cove	Wetland Replacement Gypsy Creek Realign	Upland Wall

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- Protection of Human Health and Environment
- Long Term Effectiveness and Permanence
- Short Term Effectiveness
- Reduction of Toxicity, Mobility and Volume Through Treatment
- Implementability
- Cost

Table E-2 summarizes the results of this analysis for the combined soil and groundwater alternatives, and Table E-3 summarizes the results for the combined sediment and containment wall alternatives.

The alternatives were then combined into 12 possible site-wide combinations. These are as follows:

Alternative #1: AC0 + BD1	No Soil Treatment and containment of sediments in a 2.9-acre confined disposal facility (CDF)
Alternative #2: AC0 + BD2	No Soil Treatment and Nearshore Containment in a 0.5-acre confined disposal facility
Alternative #3: AC0 + BD3	No Soil Treatment and Upland Treatment/disposal of sediments
Alternative #4: AC1 + BD1	Hazardous Waste Treatment and CDF
Alternative #5: AC1 + BD2	Hazardous Waste Treatment and Nearshore Containment
Alternative #6: AC1 + BD3	Hazardous Waste Treatment and Upland Treatment/Disposal of Sediments
Alternative #7: AC2 + BD1	Nearshore DNAPL Treatment and CDF
Alternative #8: AC2 + BD2	Nearshore DNAPL Treatment and Nearshore Containment
Alternative #9: AC2 + BD3	Nearshore DNAPL Treatment and Upland Treatment/Disposal of Sediments

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Table E-2 Detailed Evaluation of Soil and Groundwater Remedial Alternatives

Alternative	Long-Term Effectivness	Short-Term Effectivness	Reduction in Mobility,Toxicity and Volume	Ability to Implement	Cost
AC0 No Soil Treatment	Potential long-term exposure concerns LOW	Limited short-term exposure for workers HIGH	Minimal contaminant volume reduction (0 tons PAH) TPAH 95% UCL 9,862 mg/kg LOW	Easy to implement HIGH	$10.4 M
AC1 Hazardous Waste Treatment	Potential long-term exposure concerns LOW	Limited short-term exposure for workers HIGH	Minimal contaminant volume reduction (9 tons PAH) TPAH 95% UCL 5,169 mg/kg LOW	Easy to implement HIGH	$11.1 M
AC2 Nearshore DNAPL Treatment	Reduced long-term exposure concerns near receptor MODERATE	Some short-term exposure for workers MODERATE	Limited contaminant volume reduction (174 tons PAH) TPAH 95% UCL 3,601 mg/kg MODERATE	Requires temporary piling and dewatering for excavation MODERATE	$12.8 M Excavation & Thermal $12.6 M In-Situ Stabilization
3 All DNAPL Treatment	Limited long-term exposure concerns HIGH	Significant short-term exposure for workers LOW	Significant contaminant volume reduction (543 tons PAH) TPAH 95% UCL 886 mk/kg HIGH	Requires temporary piling and dewatering for excavation LOW	$14.3 M Excavation & Thermal $15.6 M In-Situ Stabilization

Notes: All remedies meet the minimum threshold of effectiveness provided that they are applied in conjunction with suitable groundwater and containment wall remedies.

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Table E-3 Detailed Evaluation of Sediment and Containment Wall Remedial Alternatives

Alternative	Long-Term Effectivness	Short-Term Effectivness	Reduction in Mobility,Toxicity and Volume	Ability to Implement	Cost	Notes
BD1 CDF	Only North Sump remains long-term concern HIGH	Some short-term exposure for workers MODERATE	Limited volume reduction since PAH-impacted sediment is contained LOW	Requires construction of in-water berm MODERATE	$9.6 M Mechanical $9.5 M Hydraulic	Contains all impacted sediment and NAPL except North Sump
BD2 Nearshore Containment	North Sump and Quendall remain as long-term concerns MODERATE	Some short-term exposure for workers MODERATE	Significant PAH volume reduction MODERATE	Requires placement of containment area in-water MODERATE	$11.1 M Mechanical $11.3 M Hydraulic	Some NAPL remains beyond wall at North Sump and Quendall
BD3 Dredging	Only North Sump remains long-term concern HIGH	Some short-term exposure for workers MODERATE	Near complete PAH volume reduction HIGH	Requires extensive dredging in the Quendall nearshore MODERATE	$13.5 M Mechanical $13.7 M Hydraulic	Removes all impacted sediment NAPL remains at North Sump and Quendall

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Alternative #10: AC3 + BD1	All DNAPL Treatment and CDF
Alternative #11: AC3 + BD2	All DNAPL Treatment and Nearshore Containment
Alternative #12: AC3 + BD3	All DNAPL Treatment and Upland Treatment/Disposal of Sediments

Table E-4 presents a summary of the 12 site-wide alternatives. The alternatives range in costs from $18.6 million to $28 million. The more expensive alternatives provide a greater degree of contaminant removal; however, they are considerably more difficult to implement and may have adverse short-term impacts which would require mitigation and/or specific water quality variances.

Table E-4 Summary Evaluation of Site-Wide Remedial Alternatives

Site-Wide Remedial Alternative	Long-Term Effectiveness	Short-Term Effectiveness	Reduction in Mobility, Toxicity and Volume	Ability to Implement	Cost
Alternative #1 - AC0 + BD1	Low High	High Moderate	Low Low	High Moderate	$18.6 M
Alternative #2 - AC0 + BD2	Low Moderate	High Moderate	Low Moderate	High Moderate	$20.0 M
Alternative #3 - AC0 + BD3	Low High	High Moderate	Low High	High Moderate	$23.3 M
Alternative #4 - AC1 + BD1	Low High	High Moderate	Low Low	High Moderate	$19.3 M
Alternative #5 - AC1 + BD2	Low Moderate	High Moderate	Low Moderate	High Moderate	$21.1 M
Alternative #6 - AC1 + BD3	Low High	High Moderate	Low High	High Moderate	$24 M
Alternative #7 - AC2 + BD1	Moderate High	Moderate Moderate	Moderate Low	Moderate Moderate	$21.1 M
Alternative #8 - AC2 + BD2	Moderate Moderate	Moderate Moderate	Moderate Moderate	Moderate Moderate	$22.9 M
Alternative #9 - AC2 + BD3	Moderate High	Moderate Moderate	Moderate High	Moderate Moderate	$25.8 M
Alternative #10 - AC3 + BD1	High High	Low Moderate	High Low	Low Moderate	$23.3 M
Alternative #11 - AC3 + BD2	High Moderate	Low Moderate	High Moderate	Low Moderate	$25.1 M
Alternative #12 - AC3 + BD3	High High	Low Moderate	High High	Low Moderate	$28.0 M

NOTE: All remedies meet the minimum threshold of protectiveness.

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1 Introduction

This document presents a focused Feasibility Study (FS) for the Port Quendall Project Area performed by Remediation Technologies, Inc. (RETEC) for Port Quendall Company (PQC) (a.k.a. JAG Development, Inc.). The work was conducted in cooperation with the Washington State Department of Ecology (Ecology) and other regulatory and resource agencies in the context of negotiations for a Prospective Purchasers Agreement (PPA) and an associated Consent Decree. The FS discusses site history, geology, hydrology, current environmental conditions and evaluates remedial alternatives for soil, groundwater and sediment contamination existing within the Port Quendall project area against criteria defined by the Model Toxics Control Act (MTCA; WAC 173-350 and 173-360). The site is located on the eastern shore of Lake Washington in Renton, Washington (Figure 1-1). The Port Quendall project area is illustrated in more detail on Figure 1-2.

The submittal of this FS to Ecology and the other agencies addresses several required elements for the initial and detailed PPA submittals pursuant to Ecology's *Prospective Purchaser Agreement Interim Policy* (1994c).

1.1 Scope of the PQC Due Diligence Process

PQC is considering the purchase of four properties located along the eastern shore of Lake Washington. These properties, collectively referred to as the Port Quendall project area, include the following:

- J. H. Baxter (North and South Parcels)
- Quendall Terminals Property
- Barbee Mill
- Pan Abode

PQC has entered into purchase and sale contracts or option agreements with the current owners of the Baxter, Quendall and Pan Abode properties. Separate negotiations are underway to finalize an agreement for the Barbee Mill property.

Prior to completing the purchase of the properties, PQC is completing a 1-year due diligence process that runs through November 4, 1997. The objective of the due diligence process is to assess the feasibility of redeveloping the subject properties into a mixed-use, high-technology "campus." A critical portion of the due diligence process is to determine the costs and other resources required to

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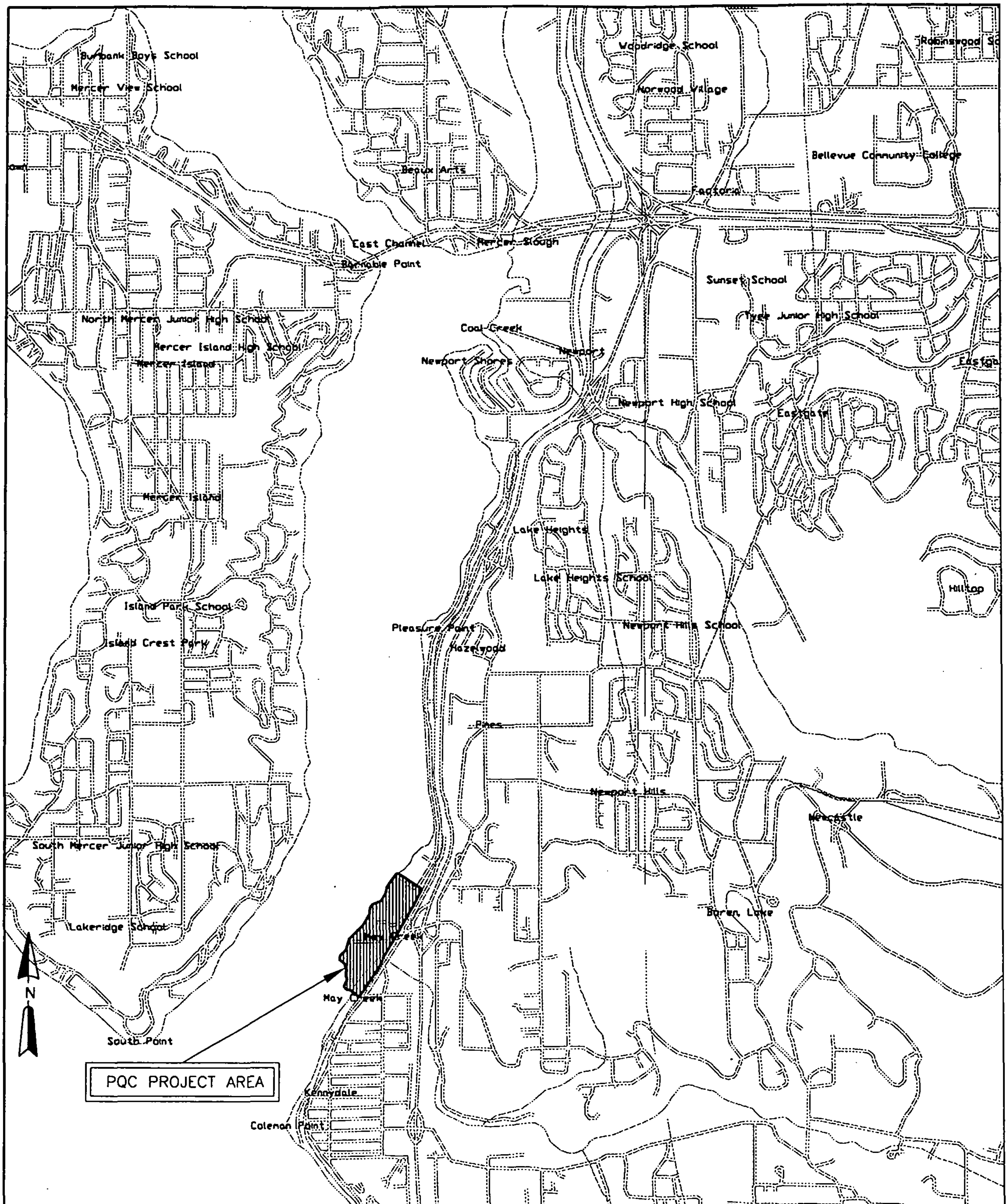

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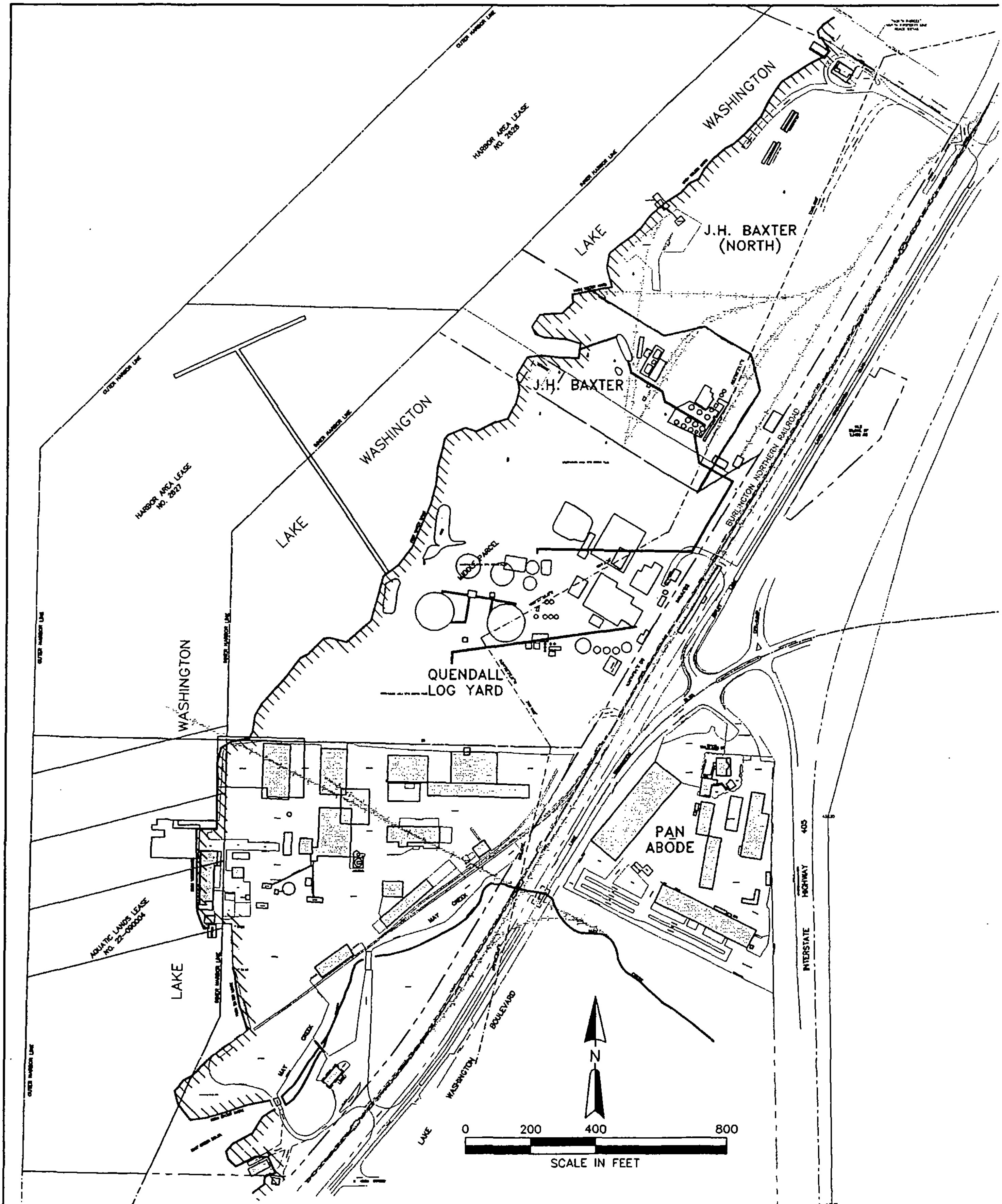

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PROPERTIES WITHIN THE
PORT QUENDALL PROJECT AREA

RETEC
REMEDIATION TECHNOLOGIES INC

FIGURE 1-2

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comprehensively address all MTCA and related environmental liability issues associated with the subject properties.

During the due diligence period, PQC has worked with the property owners, Ecology and other resource agencies under the PPA framework in order to determine what measures will be required to address environmental contamination problems prior to redevelopment of the properties.

Soil, groundwater and sediment contamination resulting from past site activities is known to exist on the Quendall Terminals and Baxter properties. A state-led cleanup process is in progress and extensive environmental data are available for these properties. After reviewing the findings of the state-led cleanup process to date, PQC concluded that a Consent Decree would be the only administrative approach that could satisfactorily address PQC's MTCA liability concerns relating to the pending purchase of these two properties. PQC selected the PPA process as the best available mechanism to obtain agency input regarding the site cleanup requirements for these properties.

The development of a Consent Decree requires the completion of several tasks, including this FS and preparation of a Cleanup Action Plan (CAP). The Consent Decree will be simultaneously negotiated to implement the CAP and to comprehensively address site liability issues. The content of the CAP and the content, form and timing of the Consent Decree will be developed during the remainder of the 1-year due diligence process.

The schedule for a CAP and Consent Decree is predicated on the construction schedule for Phase 1 of the Port Quendall redevelopment project. This phase of project construction must be completed and the buildings ready for occupancy by November of 1999. In order to meet this schedule, the remedial work in the uplands must be initiated by March of 1998. The CAP and Consent Decree must be in place prior to initiation of this remedial work.

1.2 Scope of this Feasibility Study

This FS is intended to address environmental contamination problems within the Port Quendall project area, particularly those associated with the Baxter and Quendall properties. In addition, during the due diligence process, Ecology expressed concern regarding the potential presence of wood waste in harbor sediments adjacent to the Barbee Mill property. After consultation with and authorization by the owners of Barbee Mill and the Department of Natural Resources (DNR), sediment sampling data for this area were incorporated into the Port Quendall feasibility study analysis

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The objective of the FS is to develop several protective remedial alternatives for the site from which Ecology and PQC will develop the preferred remedial alternative. If PQC elects to purchase the subject properties, this alternative will then be implemented with a CAP and Consent Decree.

Ecology has provided regulatory oversight for the FS process under a Prepayment Agreement with PQC signed in October of 1996. Additional regulatory and resource agencies which have also participated in the FS process are:

- U. S. Army Corps of Engineers
- Washington State Department of Natural Resources
- U.S. Environmental Protection Agency (EPA)
- Muckleshoot Tribe
- Washington State Department of Fisheries
- U.S. Department of Fish and Wildlife

This FS fulfills MTCA and the state's Sediment Management Standards (SMS) (WAC 173-204) requirements and supports PQC's hybrid initial/detailed submittal to Ecology under Ecology's Prospective Purchaser Agreement Interim Policy (1994). The FS also:

- Provides a summary of the site conditions and presents a conceptual model for site geology, hydrology, and contamination

- Introduces PQC's preliminary remedial action objectives, including both regulatory requirements as well as the additional expectations expressed by resource agencies during discussions with PQC

- Presents the remedial technologies evaluated for soil, groundwater, and sediment remediation and indicates those technologies that will continue to be considered for remediation, as well as those used to develop cost estimates for the FS

- Presents the procedures used for evaluation and the evaluation of a focused set of remedial alternatives

1.3 Disclaimer

As described in the previous section, state-led regulatory actions are in progress at the Baxter and Quendall sites. The PQC due diligence work and FS are separate from those state-led actions.

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Any work or work product addressed in this document or cross-referenced herein and performed or to be performed by PQC in the identified Port Quendall project area has or will be undertaken only for purposes of determining the feasibility of the Port Quendall redevelopment project. This analysis may not be applicable for other developments with different land use plans.

PQC and RETEC are submitting this document with the understanding that no independent liabilities shall be assumed by PQC under MTCA or any comparable federal or state environmental laws should PQC elect not to complete purchase of the four subject properties.

1.4 Site History

A review of historical information and environmental records for the Baxter, Quendall, and Barbee Mill properties is summarized herein. Phase I Environmental Site Assessments for the Pan Abode property have been performed by Earth Consultants (1991) and GeoGroup Northwest (1996). A summary of this information is provided in the following sections.

1.4.1 Early History of the Project Area

In 1873, Jeremiah Sullivan obtained all of the subject parcels from the U.S. government and sold them in 1875 to James M. Colman. In 1902, the timber on the subject parcels was sold, and in 1903, a right-of-way was deeded to Northern Pacific. The Northern Pacific rail line later became the Burlington Northern track which currently intersects the project area.

The four subject properties remained within the Colman family through at least 1908, when ownership of the subject parcels began to diverge. Peter Reilly took title to most of the waterfront parcels in March of 1916. Between July and October of 1916, the Army Corps of Engineers completed the Lake Washington Ship canal, which lowered the level of Lake Washington by approximately 8 ft (US Geological Survey, 1983). This increased the land area of the waterfront parcels, by exposing formerly submerged portions of the May Creek Delta.

Between 1920 and 1936, the location of May Creek was moved southward. As noted in the 1895 United States Geological Survey (USGS) and 1914 DNR maps, the original creek bed was located in the middle of the current Quendall Terminals property. By 1936, this original channel had been partially filled, and the creek rerouted to a location roughly at the midpoint of the current Barbee Mill property. By 1946, the creek had once again been rerouted further to the south. A final southerly adjustment between 1946 and 1956, placed the creek in its current location.

CP 000944

1.4.2 Barbee Mill Property

The Colman family and the Lake Washington Mill company both held title to portions of the Barbee Mill property during the 1920s, with the property deeded to Barbee Marine Yards in May of 1943. The Barbee Shipyard was active during World War II constructing wooden barges, tugs and other vessels for the war effort. An aerial photograph from 1946 showed approximately 60 boats moored on the lake in front of the shipyard, suggesting that the shipyard was also used to scrap WW II surplus boats, a common activity at shipyards around the Puget Sound area following the war. This photograph also showed that the southwestern portion of the Barbee property was used as a lumber mill, as evidenced by log rafting on the water and stacks of cut lumber on shore. A deed from June of 1945 recorded the transfer of property from Barbee Marine Yards to Barbee Mill Company. From this date to the present the property has been used as a lumber mill, producing standard and metric-cut lumber for domestic and international markets.

Attempts to develop the Port Quendall area in the 1970s and 1980s included the Barbee Mill property. As part of these redevelopment efforts, various geotechnical and environmental investigations were conducted (RETEC, 1996b). King County Department of Metropolitan Services (Metro) activities along May Creek resulted in early investigation of sediment and stormwater quality. In January of 1976, Metro conducted an evaluation of the sediments at the mouth of the creek, including a SCUBA survey and texture analysis of sediment samples. The report noted that approximately 3,000 cubic yards (cy) of sediment are deposited annually in the lower reach of May Creek.

1.4.3 J. H. Baxter Property

The current J. H. Baxter property was essentially undeveloped until the mid-1950s, when a wood treating facility was constructed on the site. All property histories indicate that both creosote and pentachlorophenol (PCP) treating solutions were used at the site, until wood treating operations ceased in the mid-1980s. Creosote was used to treat railroad ties and pilings, and PCP solutions were used to treat utility poles. Treated wood was stored predominantly on the southern portion of the Baxter property, and distributed to purchasers by rail or truck. Figure 1-3 provides the locations of the J. H. Baxter process areas discussed below.

Butt Tanks

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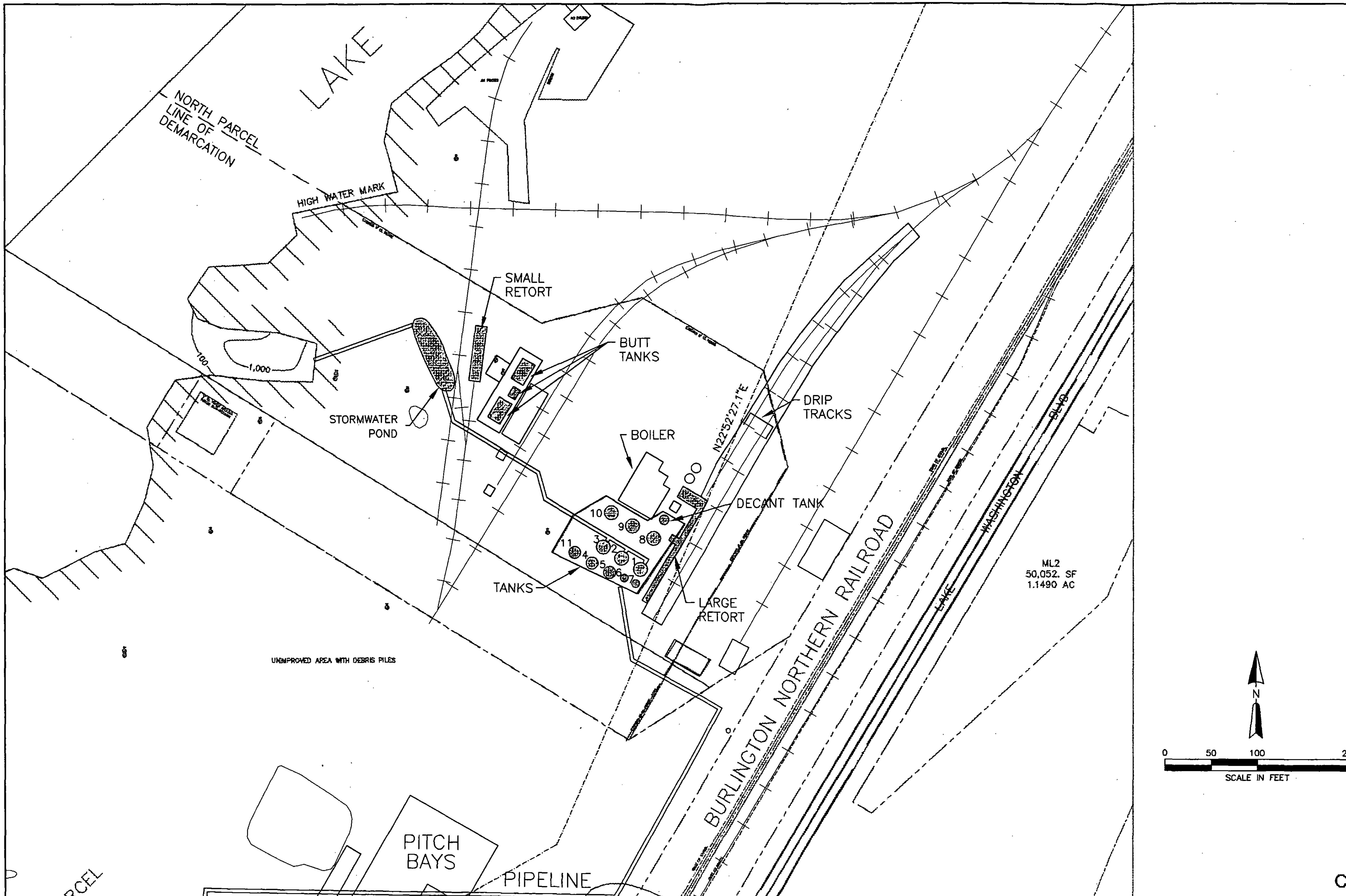
The plant was built in 1955 and originally operated three butt tanks, using creosote as a preservative. No secondary containment structures were placed



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J.H. BAXTER
PROCESS AREAS

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REMEDIATION TECHNOLOGIES INC

DRAWING NO FIGURE 1-3 REV. 0

around the butt tanks. Hot creosote oil, heated by a boiler near the tank farm, was pumped into the butt tanks through underground piping from the creosote storage tank in the tank farm. The hot oil was then pumped out and replaced with cold creosote oil, which was drained from the tank after treatment was complete. The butt tanks were taken out of service in December 1970 and were reportedly abandoned in place in 1979.

Small Retort

In approximately 1960, a small retort, estimated to be 6 ft in diameter by 45 ft long, was installed using PCP for the preservative. It was located between the butt tanks and Lake Washington, and the door of the retort faced to the south. No secondary containment structures were constructed around the retort. Wood poles were treated by the Boulton process using a diluted solution of PCP in an aromatic carrier oil. The wood was chemically pre-conditioned and treated and the treated wood was drained; this work was all performed in the same vessel. Use of this retort was discontinued in April 1970 and the retort was reportedly removed from the site in 1977.

Large Retort

In 1965, the large retort (8 ft diameter by 144 ft) was installed for use with PCP and creosote. Creosote was not used after 1975. Also, light solvent treatment using mineral spirits as a carrier was used at the plant for one charge. In August of 1981, the plant was shut down and the retort was moved to Arlington, Washington.

Drip Tracks

Former drip tracks are assumed to be associated with the large retort. The exact location and dimensions of the area are unknown, although stained soil has been observed near the railroad tracks to the north of the large retort. Additional test pitting investigations were performed by RETEC on the North Baxter portion of this area (RETEC, 1997g).

Tank Farm

During the course of plant operation, five to eleven aboveground storage tanks of varying capacities were located near the operations buildings in the tank farm. The tank farm was contained with a concrete slab and berm. Wood preserving chemicals stored in the tank farm included crystalline PCP, aromatic carrier oils, 5 percent PCP in solution, and creosote. A map from 1962 indicates that Tank 1 contained petroleum, Tanks 2 and 3 contained creosote, Tank 4 contained concentrated PCP, and Tank 5 was the working PCP tank.

CP 000947

Process Wastes

A 1965 waste discharge permit for Baxter (Permit No. 2164) indicated that a discharge of up to 21,000 gallons per day of cooling and contaminated waters was allowed. The permit also required that oils and other wastes should be prevented from entering the lake. Chemical sludges or sludge contaminated oils were to be disposed of on land and not discharged to a State waterway.

A waste discharge permit from 1970 allowed discharge of up to 24,400 gallons of waste per day following treatment and in-plant control. The permit application described the on-site use of creosote from Reilly Tar, PCP from Monsanto Chemical, and medium aromatic oil from Shell. The application also described a separating tank from which oil components of treatment condensate were drained and pumped back to the storage tank. The water from the separating tank was then drained into a skimming and settling pond where any remaining oil was eliminated by skimming the surface oil and settling any oil heavier than water. The effluent from this tank was siphoned off below the surface into a pipe going to Lake Washington.

A waste discharge permit from 1971 covered only discharge of sanitary wastes to a septic system on site. Baxter indicated on the application that there was no cooling water or process water discharge to the Lake at the time of the application. The permit indicated that "no industrial wastes are being discharged directly into state waters, only stormwater run-off." The permit application included a schematic which supported the no-discharge claims. The permit also indicated that collection troughs had been installed in front of the butt tanks and all oily wastes and water from the butt tank area are pumped into the decantation system as part of the non-discharge recirculating cooling tower system.

1.4.4 Quendall Terminals

Industrial activities at the Quendall property commenced in 1917 with the establishment of Republic Creosoting, which refined tars generated by the Lake Union manufactured gas plant (and others) into creosote and other refined tar products. The name of the facility was changed to Reilly Tar & Chemical and operated as a refinery until 1969. After refining operations ceased, some of the aboveground tanks at the site were used to store fuel for a variety of companies into the mid-1970s. The tank farms were dismantled and sent to a disposal facility in Idaho in 1983, and the site was graded and raised with approximately 3 ft of a soil and wood mixture. The property has since been used for log sorting and storage. Figure 1-4 provides the locations of the Republic Creosoting and Reilly Tar & Chemical process areas discussed below.

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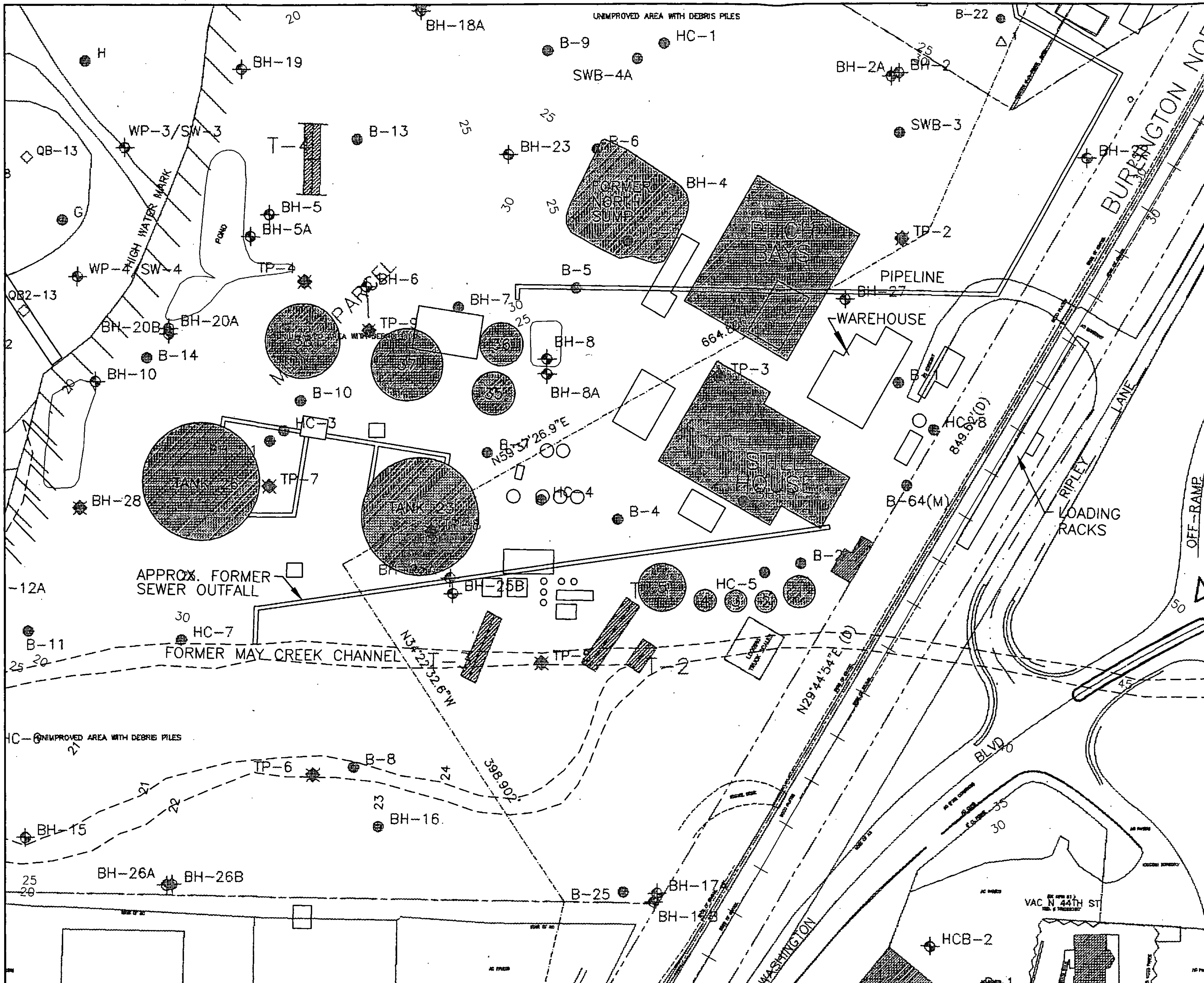

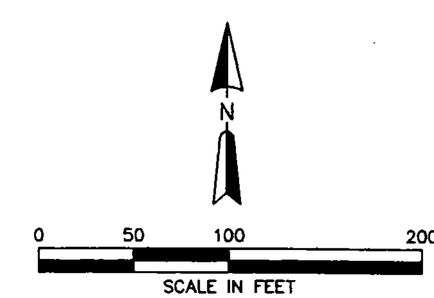

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REPUBLIC CREOSOTING/
REILLY TAR
PROCESS AREAS

RETEC
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DRAWING NO. FIGURE 1-4 | REV 0

The DNR maps compiled in 1920 clearly show the original Republic Creosoting refinery and storage tanks. The still house was located to the west of the brick office building, which is the only structure from the Republic Creosoting refinery remaining at the site. Four aboveground storage tanks were located to the southwest of the office. The 1920 maps show a pipeline connecting the short dock to the still house, and another line connecting the still house and the storage tanks. The original bed of May Creek was present immediately to the south (approximately 100 ft) of the four storage tanks.

By 1936 (first available aerial photograph), the operations of Republic Creosoting had expanded. The photograph shows that the bed of May Creek had been rerouted to the south by this time. Additional storage tanks had been constructed, including the two largest tanks (reportedly 2 million gallons each). The tanks of the north tank farm had not been constructed, nor had berms been constructed around the large tanks. The still house and adjacent buildings had been expanded, a sump was installed to the northwest, and the T-Dock was constructed for off-loading of tankers.

Records at the Washington Archives identify the construction dates for the largest tanks, the T-Dock and several of the buildings. The pipeline from the T-Dock to the shore is shown in these records as a 6-inch-diameter pipe. The tar was commonly shipped to the site and pumped through a transfer line that ran along a former wharf and pipe trestle to two 2 million-gallon storage tanks (Tanks 23 and 26) located in the west central tank area. Tankers were off-loaded at the T-dock and barges were off-loaded at the short pier. The tanks contained heating elements that would allow the liquid material to be transferred to the still house where the tars were refined to produce creosote and distillates. The products were stored in tanks until shipment by either rail, tanker truck, or ship. The tar distillates were further refined to generate naphthalenes, xylenes, benzene, toluene mix, and other organic products.

Tanks 1 through 5, located immediately south of the still house, were installed in 1916 to store creosote-related products. Tanks 23 and 26, installed in 1926, were used to store raw coal tar products. Tanks 35 through 38, located in the west central site area, were constructed in 1956 and were used primarily for storage of creosote-related products.

Potential sources of soil, groundwater, and sediment contamination include the following:

CP 000950

- The still house
- The underground pipes in the still house
- Disposal of waste pitches and "Saturday coke" by running them out onto the ground
- Spills at the end of the docks, including a release in which an estimated 30,000 to 40,000 gallons were lost into the lake off the end of the T-Dock around 1937
- The flush box and sanitary sewer outfalls
- Pitch bays (40 ft wide by 150 ft long and 4 ft deep) constructed with concrete bottoms and wooden sides and used for cooling of pitches
- The old bed of May Creek where dumping of tank cleaning residues may have occurred
- Former sumps which potentially received effluent from cooling lines contaminated with creosotes and tars

Petroleum Storage

The Potentially Liable Party (PLP) search performed by Ecology tracked land use at the site between 1970 and 1982, and listed the following companies that were reported to have stored products at the facility:

- Boeing
- Lidcoa Company
- Superior Refinery
- Seattle Rendering (tallow only)
- QED Corporation
- United Drain Oil, Metro, King County, Fort Lewis
- Golden Penn Refineries
- Western States, Willamette Industries
- Turbo Energy Systems
- Northwest Services, Inland Transportation, Pacific Gamble Robinson

Tanks 23 and 26 were used for about 18 months around 1974 for the storage of Bunker Crude oil. Tanks 35 through 38 were the principal tanks used for storage of diesel and waste oils until 1978.

CP 000951

1.4.5 Pan Abode Property

The Pan Abode property was owned by Reilly Tar & Chemical, owners and operators at the adjacent Quendall property, until 1957 when it was purchased by the Pan Abode company for use in manufacturing prefabricated cedar homes. Prior to this time the property was undeveloped, and there is no indication that it was ever used by Reilly Tar & Chemical in their tar refining process.

The facility is still used for manufacturing cedar homes, with some areas of the property also used for storing large boats and motor homes. Former activities at the site which might have impacted soil or groundwater include the use (until the mid-1970s) of Pen-a-Seal, a wood sealant/preservative which contains PCP, and the use of two underground storage tanks (UST) from the late 1970s until the late 1980s. One UST was used for gasoline and one for diesel storage. Phase I Environmental Site Assessments were conducted on the property by Earth Consultants (1991) and GeoGroup Northwest (1996).

2 Current Site Conditions

2.1 Hydrogeologic Setting

2.1.1 Regional Geology

The project area is located within the Puget Sound Basin, which is situated between the Olympic Mountains to the west and the northern Cascade Range to the east. The regional topography and subsurface geology have been extensively shaped by Pleistocene glaciation, with at least five major advances of glacial ice from the south across the Puget Sound Basin (Galster & Laprade, 1991). These glacial advances and retreats, along with interglacial periods of erosion and deposition have produced a very complex mixture of drift, till and outwash sediments combined with fluvial, lacustrine and mud flow deposits.

The Vashon Glaciation is the most recent of these episodes, and the Vashon Drift mantles much of the surface within the Puget Sound Basin and northward into Canada. The Vashon Drift is generally differentiated into four members: the Lawton Clay, Esperance Sand, Vashon Till and Vashon Recessional deposits. In some lower-lying areas, these members have been eroded or covered by Holocene lacustrine and fluvial deposits.

Physiographic divisions made by Galaster and Laprade (1991) place the project area within the southeast-northwest trending Kennydale Channel, which bisects the Newcastle Hills promontory to the north from the Coalfield Drift Upland to the south and terminates on the eastern edge of the Lake Washington Trough. Glacial troughs such as the Kennydale Channel typically include high energy Vashon recessional deposits of coarse sand, gravel and cobbles with some deeper, glacially compacted till possibly present, all overlain by Post-Vashon fluvial and lacustrine deposits of gravel, sand, silt, clay and peat.

Bedrock has been locally mapped at or near the surface in a generally east-west trend, forming Alki Point in West Seattle, Beacon Hill in Seattle and the Newcastle Hills east of Lake Washington and then continuing east toward the northern Cascades. The core of the Newcastle Hills promontory is composed of middle to late Eocene Tukwila and Renton Formations of the Puget Group. The Tukwila Formation consists of volcaniclastic sandstone, siltstone and shale, with the conformably overlying Renton Formation composed of arkosic sandstone, siltstone, shale and coal (USGS, 1970). Extractable coal seams in the Renton and Black Diamond areas ranged from 11 to 17 ft in thickness where mining began in the early 1870s. Due to folding and faulting of the Renton Formation and undifferentiated Puget Group, the mines tended to be small and the mining conditions difficult. Subbituminous coal from the Renton Number 1, 2 and 3 seams was extracted from the Renton area, with bituminous coal mined from the McKay seam in the Black Diamond area.

2.1.2 Site Geology and Hydrology

The Port Quendall project area is located on the eastern shore of Lake Washington on the former delta of May and Gypsy Creeks, which are underfit streams remaining within the glacial Kennydale Channel. The subsurface geology of the site is a combination of fluvial deltaic, lacustrine nearshore and constructed fill deposits overlying Pleistocene glacial sediments and Eocene volcanic and sedimentary bedrock. The shallow geology at the project area has been heavily influenced by recent human activity, beginning with construction of the Lake Washington Ship Canal in 1916. This lowered the level of Lake Washington approximately 8 ft, and exposed a significant area of the May and Gypsy Creek deltas which had formerly been submerged.

Subsequent filling of low lying areas was performed to extend the shoreline and raise the grade for construction of industrial facilities at Quendall (1917), Barbee Mill (1943) and Baxter (1955). The source of the fill material is not well documented. May Creek has been relocated from its original position in the center of the project area to the south several times since 1916, with the former channels backfilled with a variety of soil and other material. The combination of naturally complex deltaic deposits with numerous dredging and backfilling episodes has resulted in a highly heterogeneous subsurface mixture of clay, silt, sand, gravel and cobbles, as well as discarded debris and abandoned subsurface structures from former site activities.

An interpretation of the project area subsurface geology has been made utilizing over 240 soil boring and monitoring well geologic logs and test pit sidewall descriptions which have been generated by environmental and geotechnical investigations in the area. Due to the complexity and heterogeneity of the subsurface geology, correlation of distinct stratigraphic units across the project area has not been attempted. Rather, the subsurface geology has been segregated into three zones: the upper fill zone, the intermediate silty peat zone, and the lower sand zone. These three zones encompass the subsurface interval which may have been impacted by past site activities or which could influence groundwater movement through an impacted area. Representative cross sections of the interpreted project area subsurface geology are included in this report. The north-south and east-west cross sections are presented in Figures 2-1 and 2-2, respectively.

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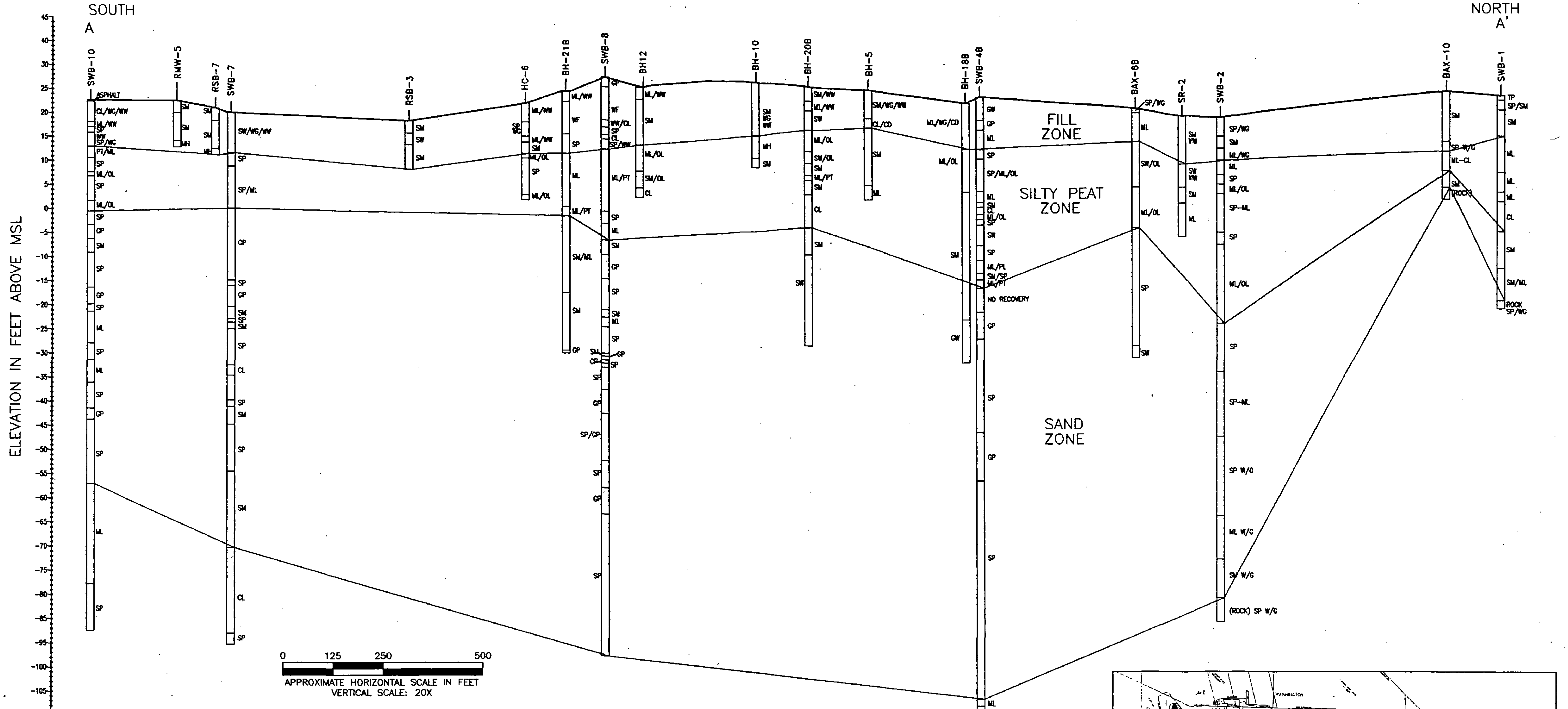


NOTES

FILL ZONE

INCLUDES (1) DREDGED FILL CONSISTING OF LOOSE-TO-MEDIUM DENSE WET SILTY FINE SAND, OR FINE TO MEDIUM SAND, AND (2) DUMPED FILL CONTAINING CLAY, SILT, SAND, GRAVEL, RUBBLE, WOOD AND OTHER DEBRIS. THE DREDGED FILL MAY BE PRESENT ALONG THE FORMER LAKE WASHINGTON SHORELINES AND APPEAR SIMILAR TO THE MAY CREEK DELTAIC DEPOSITS.

SILTY PEAT ZONE

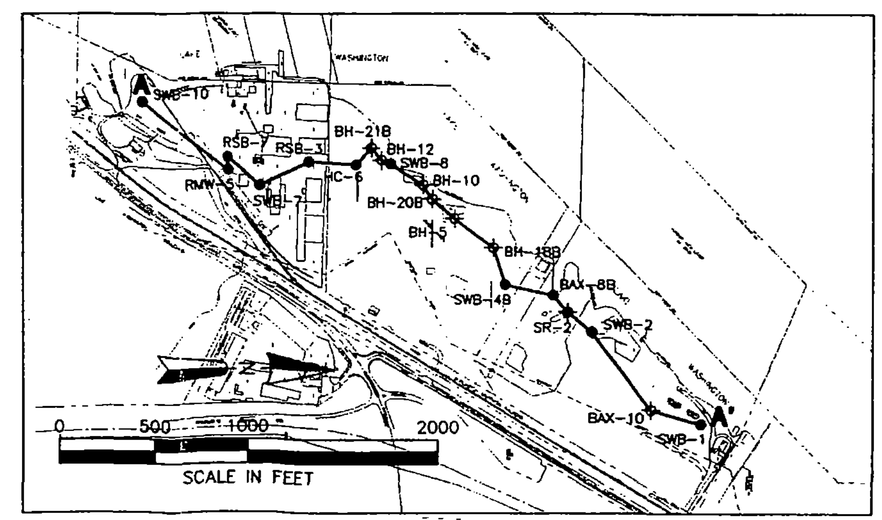
CONSISTS OF SOFT TO STIFF, DARK BROWN TO GRAY SILTY PEAT, ORGANIC WOODY SILT, AND SILTY FINE SAND WITH INTER BEDDED GRAY TO BROWN CLAY, SILT, SAND, AND OCCASIONAL ASH LENSES.

SAND ZONE

CONSISTS OF GRAY DENSE, TO MEDIUM DENSE, FINE TO COARSE GRAINED SAND, AND GRAVEL WITH COBBLES, AND INTER BEDDED GRAY SILTY FINE GRAINED SAND, AND SILT LENSES.

LEGEND

ML=SILT/SANDY SILT	WG= WITH GRAVEL
MH=CLAYEY SILT	GW=WELL GRADED GRAVEL
OL=ORGANIC SILT	GP=POORLY GRADED GRAVEL
CL=LEAN CLAY	SW=WELL GRADED SAND
CH=FLAT CLAY	SP-SM=POORLY GRADED
WF=WHITE FLY ASH	SM=SILTY SAND
WW=WOOD WASTE	SC=CLAYEY SAND
PT=PEAT	CD=CONSTRUCTION DEBRIS



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PORT QUENDALL
NORTH-SOUTH SITE
CROSS SECTION

RETEC REMEDIATION TECHNOLOGIES INC

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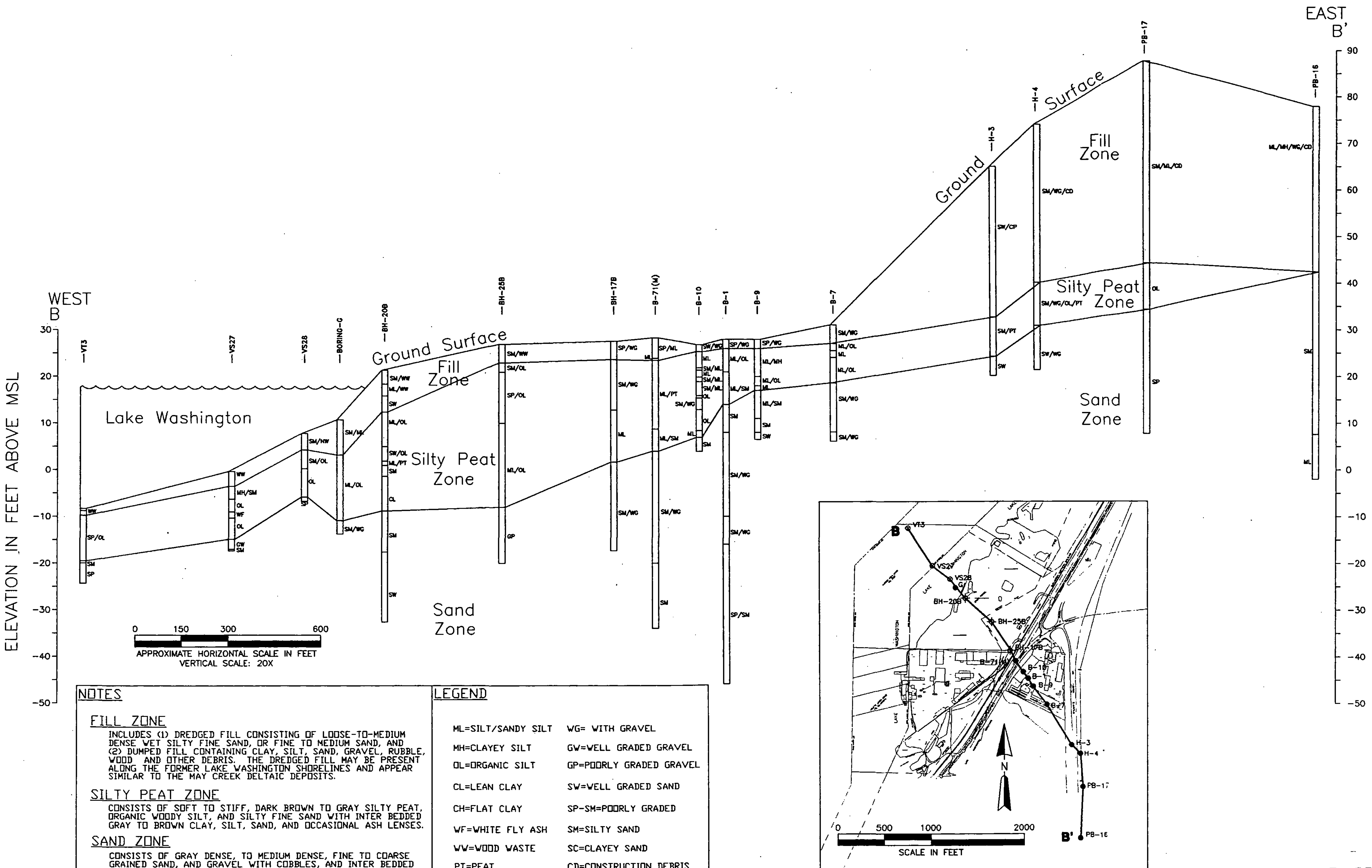

NOTES

FILL ZONE

INCLUDES (1) DREDGED FILL CONSISTING OF LOOSE-TO-MEDIUM DENSE WET SILTY FINE SAND, OR FINE TO MEDIUM SAND, AND (2) DUMPED FILL CONTAINING CLAY, SILT, SAND, GRAVEL, RUBBLE, WOOD AND OTHER DEBRIS. THE DREDGED FILL MAY BE PRESENT ALONG THE FORMER LAKE WASHINGTON SHORELINES AND APPEAR SIMILAR TO THE MAY CREEK DELTAIC DEPOSITS.

SILTY PEAT ZONE

CONSISTS OF SOFT TO STIFF, DARK BROWN TO GRAY SILTY PEAT, ORGANIC WOODY SILT, AND SILTY FINE SAND WITH INTER BEDDED GRAY TO BROWN CLAY, SILT, SAND, AND OCCASIONAL ASH LENSES.

SAND ZONE

CONSISTS OF GRAY DENSE, TO MEDIUM DENSE, FINE TO COARSE GRAINED SAND, AND GRAVEL WITH COBBLES, AND INTER BEDDED GRAY SILTY FINE GRAINED SAND, AND SILT LENSES.

LEGEND

ML=SILT/SANDY SILT	WG= WITH GRAVEL
MH=CLAYEY SILT	GW=WELL GRADED GRAVEL
OL=ORGANIC SILT	GP=POORLY GRADED GRAVEL
CL=LEAN CLAY	SW=WELL GRADED SAND
CH=FLAT CLAY	SP-SM=POORLY GRADED
WF=WHITE FLY ASH	SM=SILTY SAND
WW=WOOD WASTE	SC=CLAYEY SAND
PT=PEAT	CD=CONSTRUCTION DEBRIS

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PORT QUENDALL
EAST-WEST SITE
CROSS SECTION

RETEC REMEDIATION TECHNOLOGIES INC

DRAWING NO. FIGURE 2-2 REV 0

The upper fill zone ranges in thickness across the project area from 0 to 14 ft, with greater thicknesses in the southern segment of the project area and along the Lake Washington shoreline. The fill zone includes dredged material consisting primarily of silty- to medium-grained sand, as well as imported material including clay, silt, sand, gravel, construction rubble, wood and other debris. The dredged fill appears very similar to May Creek deltaic deposits and it is difficult to differentiate without the presence of discarded debris or other obvious indicators. In most of the site, the fill zone corresponds to the unsaturated zone, although some sections of fill material are located below the shallow water table.

The intermediate silty peat zone is comprised of soft to stiff dark brown to gray silty peat, organic woody silt and silty fine-grained sand with interbedded gray and brown clay, silt, sand and occasional ash lenses. This silty peat zone is most prominent in the northern segment of Quendall Log Yard and the southern and central areas of the J. H. Baxter property, and is thin or not present at all on the southern, northern and eastern edges of the project area. The silty peat zone was encountered in soil borings with thicknesses between 0 to 35 ft, and was noted at depths between 0 and 14 ft below ground surface (bgs). This layer shows a high degree of heterogeneity both vertically and horizontally due to changes in the May Creek channel alignment over time and is saturated over most of its depth. Water levels in wells that intercept the upper fill and silty peat zones are shallow and relatively stable, with depths to water generally less than 10 ft and seasonal variations of less than 3 ft. The shallow groundwater contour map for the project area is shown on Figure 2-3.

The lower sand zone consists of gray dense to medium dense, fine- to coarse-grained sand and gravel with cobbles and interbedded gray and brown silty fine-grained sand and silty lenses. This zone ranges in thickness between 6 and 93 ft and is thickest in the central segment of Quendall property extending eastward up the May Creek drainage. Over most of this aquifer, the water levels are similar to the water levels in the silt-peat layer, with seasonal variations in water levels in individual wells less than 2 ft.

Geologic material underlying the lower sand zone includes glacially compacted, very dense gravelly silts in the southern segment of the project area, soft gray clay in the central area and bedrock in the northern area. Two recent borings by Shannon & Wilson encountered flowing artesian conditions in a sand below the gravelly silt in the southern segment of the project area. Based on these deep borings, it is inferred that these borings encountered the regional Vashon Drift

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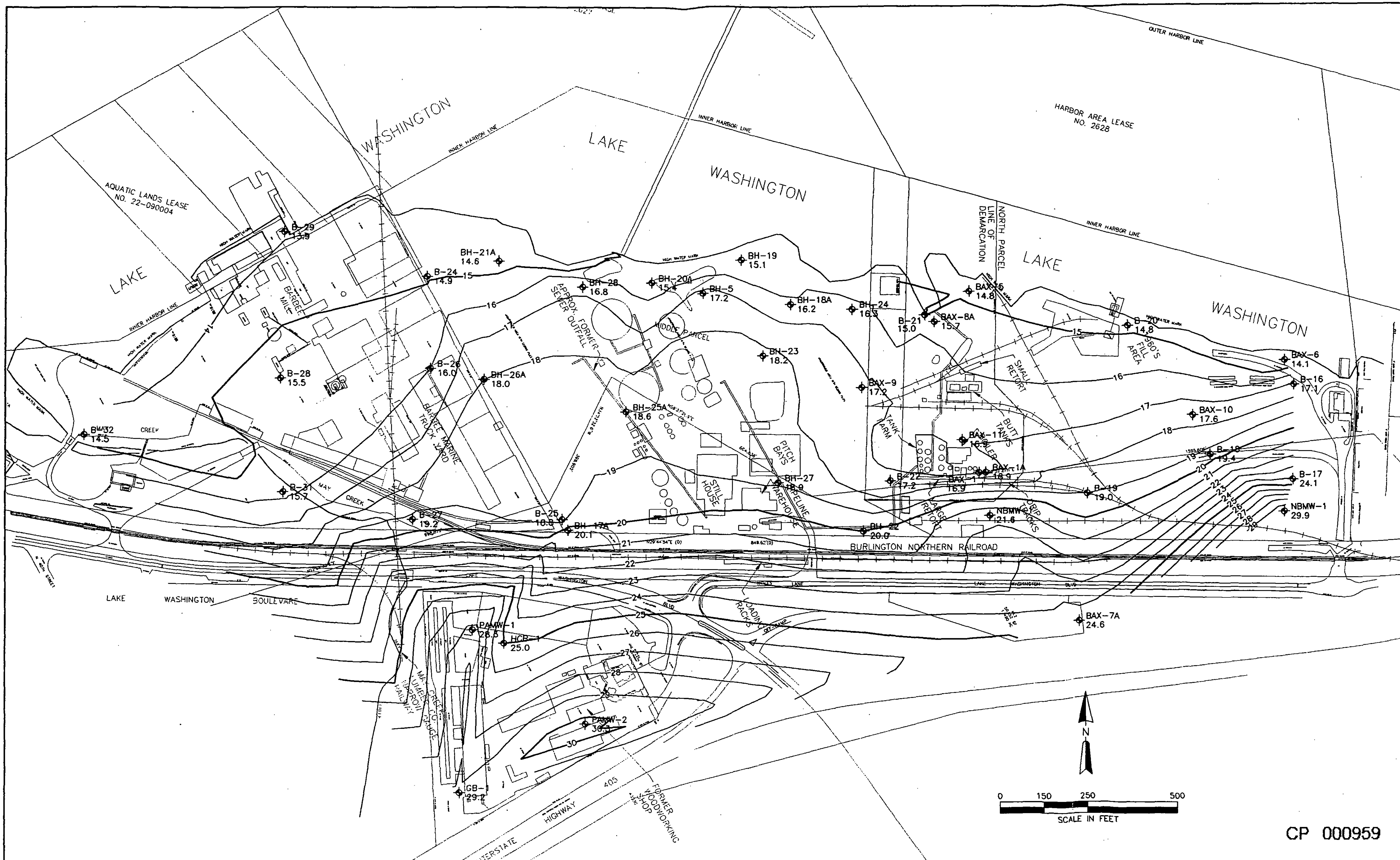

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AVERAGE SHALLOW WATER LEVELS
ELEVATIONS IN FEET ABOVE MSL

RETEC REMEDIATION TECHNOLOGIES INC

DRAWING NO. FIGURE 2-3 REV 0

deposits and that the lower sand zone is a Holocene alluvial fan deposit. This is consistent with the bathymetry of Lake Washington adjacent to the project area, which indicates an alluvial fan extending across the lake to Mercer Island. Based on the bathymetry, this alluvial fan extends to a depth of at least 80 ft below mean sea level (MSL).

Due to the depths of these materials, they are not involved in the various remediation alternatives for the project area. They are included, however, in computer modeling of the groundwater movement near and through the project area.

2.1.3 Hydrologic Model

Groundwater modeling was performed by RETEC to support the FS analysis of remedial alternatives for groundwater at the subject properties. The *Port Quendall Groundwater Model and Hydrogeologic Analysis of Alternatives* (RETEC, 1997u) describes in detail the setup of the model, its calibration, and the output from flow modeling and contaminant fate and transport analysis.

The objectives of the groundwater modeling effort were to test remedial alternatives for their impact on groundwater flow patterns and contaminant fate and transport properties. Specific questions addressed through the modeling effort included the following:

- What are the travel times for groundwater and dissolved constituents migrating between existing source areas and the points of exposure at the Lake Washington shoreline?

- What impact would the installation of various containment walls (different locations and depths were tested) have on groundwater and dissolved constituent travel times, dilution and dispersion?

- What impact would the installation of various containment walls (different locations and depths tested) have on pumping rates required to achieve groundwater capture in a pump and treat system operated in conjunction with the wall?

- What impact would the installation of containment walls have on pumping rates required to conduct upland dewatering of the site during soil excavation activities?

CP 000960

- In the absence of contaminant degradation, can dilution and dispersion be expected to reduce groundwater contaminant levels at the point of groundwater discharge to the lake adequately to achieve compliance with surface water regulatory criteria?

- How do different containment wall locations and depths impact contaminant dilution and dispersion?

- What rate of contaminant degradation must be achieved in situ to adequately attenuate groundwater contaminants prior to their discharge to the lake under various wall location and depth scenarios, and how do these rates compare to those achieved during groundwater treatability testing performed by RETEC?

- Is it feasible to use a "funnel and gate" approach to direct groundwater flow paths to specific openings in a containment wall where active treatment systems can be focused?

To answer the above questions, it was necessary to use a 3-dimensional groundwater model. This was done using the groundwater flow model, MODFLOW (McDonald and Harbaugh, 1988). Groundwater particle tracking and contaminant fate and transport modeling were performed using the MODPATH module to MODFLOW, and FATE2. Previous modeling work had been performed for the Quendall Terminals property (Hart Crowser, 1996), but that work had used a simple two-dimensional flowpath model that was inadequate for answering the questions about pumping rates, funnel and gate groundwater treatment, and contaminant dispersion. No modeling work had been performed as part of the previous remedial investigation work performed by Woodward-Clyde (1990) for the Baxter property.

Model Parameters

The groundwater model was set up using site geologic and hydrogeologic data, expanded using additional sources of information including Department of Transportation (DOT) borings, local well logs and published regional geological interpretations. The model incorporated the silty peat layers and the lower sand and gravel layer as described in Section 2.1.2. The upper fill soil layer was not included in the groundwater model, because this layer is unsaturated over most of the site. In areas where the bottom of fill is below the water table, it was treated as part of the silty peat layer.

Water level data were compiled and analyzed to characterize the seasonal variations and provide coverage for the entire model area. Water levels were used to calibrate the site model.

CP 000961

The boundaries to the model were heavily dominated by Lake Washington, which was treated as a constant head boundary. The shallow silty peat layer extends to the toe of the bluffs east of Interstate 405 where the material is largely silt and clay, and was treated as a no-flow boundary. The lower sand and gravel layers were not considered to be significantly affected by pumping in the project area and were treated as constant head boundaries. This is a conservative assumption in that the boundary will not inhibit flow into the model.

The model included surface infiltration as additional sources of groundwater recharge. Recharge through infiltration was established at 20 inches per year. May Creek was originally considered as a potential boundary to the model. However, water level data do not indicate a significant effect from May Creek as either a source of groundwater or as a discharge point for groundwater. Consequently, May Creek was not incorporated into the model.

Hydraulic conductivity data were incorporated by averaging the data over each layer. For the horizontal conductivity, the arithmetic average of the data was used. The hydraulic conductivity in the vertical direction was established at 0.01 of the horizontal value for the silty peat layer and 0.1 of the horizontal value for the lower sand zone.

The effective porosity for the silty peat layer was estimated to be between 0.28 and 0.32 at the Baxter property and at 0.30 for the Quendall Terminals property. The effective porosity of the sand was estimated to be between 0.20 and 0.25 at both properties.

Contaminants of concern selected for fate and transport modeling included benzene, chrysene and naphthalene. These contaminants were selected based on their relative toxicity, mobility, and presence at the site. The source areas used in the fate and transport evaluation were outlined in the *Upland Constituents Memorandum* (RETEC, 1997f) and are discussed in detail in the *Port Quendall Groundwater Model and Hydrogeologic Analysis of Alternatives* (RETEC, 1997u). Chemical parameters for the source areas were estimated from site groundwater sampling data and augmented by recent treatability testing (RETEC, 1997q). Chemical degradation rates and sorption coefficients for the transport modeling were obtained from the literature and augmented by the recent treatability data.

Fate and transport modeling was used to identify contaminant dilution and dispersion achievable in the absence of degradation, as well as to quantify the impact of different degradation rates on observed contaminant attenuation.

CP 000962

Model Output

The groundwater modeling report contains a detailed description of the output and conclusions. These conclusions have been incorporated where appropriate into the analysis of remedial alternatives. The major findings of the modeling effort included the following:

- Containment walls can be used to lengthen the groundwater travel time between the Quendall Pond source area and the point of exposure in the lake by a factor of between two and four. Placing the wall at the far edge of a CDF provides the longest travel time for the Quendall pond source area groundwater, and also encloses offshore DNAPL areas. Walls placed to depths of 50 feet provide only marginal lengthening of travel times over walls placed to 30 feet.

- When degradation rates for benzene were assumed to be zero, attenuation of the contaminants in the Quendall Pond Area prior to discharge to Lake Washington was not achieved under current conditions or under any of the containment wall alternatives. However, with only low degradation rates assumed (between 1 and 10 percent of those achieved during groundwater treatability testing) complete benzene attenuation can be achieved under all of the containment wall scenarios.

- The use of containment walls (temporary or permanent) reduce the pumping rates required to support deep soil excavations by 35 to 71 percent. As expected, the greatest pumping rate reduction was achieved for the Quendall Pond area which is adjacent to the Lake Washington shoreline. If flow barriers are used, the pumping rates for deep excavations are expected to range between 24 and 32 gallons per minute.

- The use of containment walls reduce the pumping rates required to achieve complete capture of the contaminated groundwater by 70 to 87 percent over current conditions. Without a containment wall, pumping rates necessary to achieve plume capture are estimated to be 145 gpm (290 gpm assuming a 2.0 contingency factor). The use of shallow walls reduces this expected pumping rate to between 35 and 44 gpm (70 to 88 gpm with contingency factor), with the lowest rates achieved using a wall placed at the outside of the CDF. Using deep walls, the estimated pumping rates range between 20 and 26 gpm (40 to 52 gpm with contingency factor), with the best performance provided by a wall placed at the outside of the CDF.

CP 000963

- The containment walls produced a vertical convergence of groundwater flow paths at the base of the walls. Several funnel and gate designs were tested for use with the various wall designs, but none were found to be effective at channeling groundwater flow through the gates.

2.2 Site Lacustrine Environment

The project area includes approximately 2,900 linear ft of Lake Washington shoreline and the use of Lake Washington has been an important component of past site activities, including barge off-loading, ship berthing and log storage. The current shoreline characteristics range from gently sloping vegetated shorelines to abrupt bulkhead or rip-rap shorelines. The Baxter, Quendall and Barbee Mill properties each have an inner and outer Harbor Lease Area. Current or former structures in these lease areas include the Baxter de-barker, the Quendall T-Dock the Barbee Mill Shipyard wharf, and Barbee Mill log rafts.

2.2.1 Lake Bottom Characteristics

As shown by the bathymetric contours on Figure 2-4, the lake bottom is relatively flat between the inner and outer harbor lines. The average slope over this interval is 3 ft vertical in 100 ft lateral. Water depths at the outer harbor line range from 26 to 31 ft (as measured at normal high water line) in most of the area. The bathymetric survey is consistent with USGS maps for the area. These show similar water depths at the outer harbor line. The USGS maps also show that on a transect toward Mercer Island from the Quendall Terminals property, the maximum water depth reached is approximately 70 ft.

The nearshore bathymetry is less uniform than that in the outer harbor area, ranging from gradual slopes to relatively steep slopes and bulkhead areas. In addition, there are bathymetric irregularities, including a shallow sand mound located offshore from the North Baxter demarcation line, a sand spit located just north of the mid-Quendall shoreline, and the irregular contours around the Barbee Mill shoreline and May Creek.

Acoustic surveys of the Harbor Lease areas confirmed that logs, log bundles and other debris are present on the lake bottom. Log densities ranged from less than 1 log per acre near the outer harbor line, to greater than 5 logs per acre near the Quendall log dump. A total of six log bundles were identified on the lake bottom.

Utility lines were located on the lake bottom offshore from the PSPL substation and the Metro interceptor pumping station. These locations are consistent with easements for those utilities. The lines are located approximately 400 ft to the northeast of the Quendall T-Dock.

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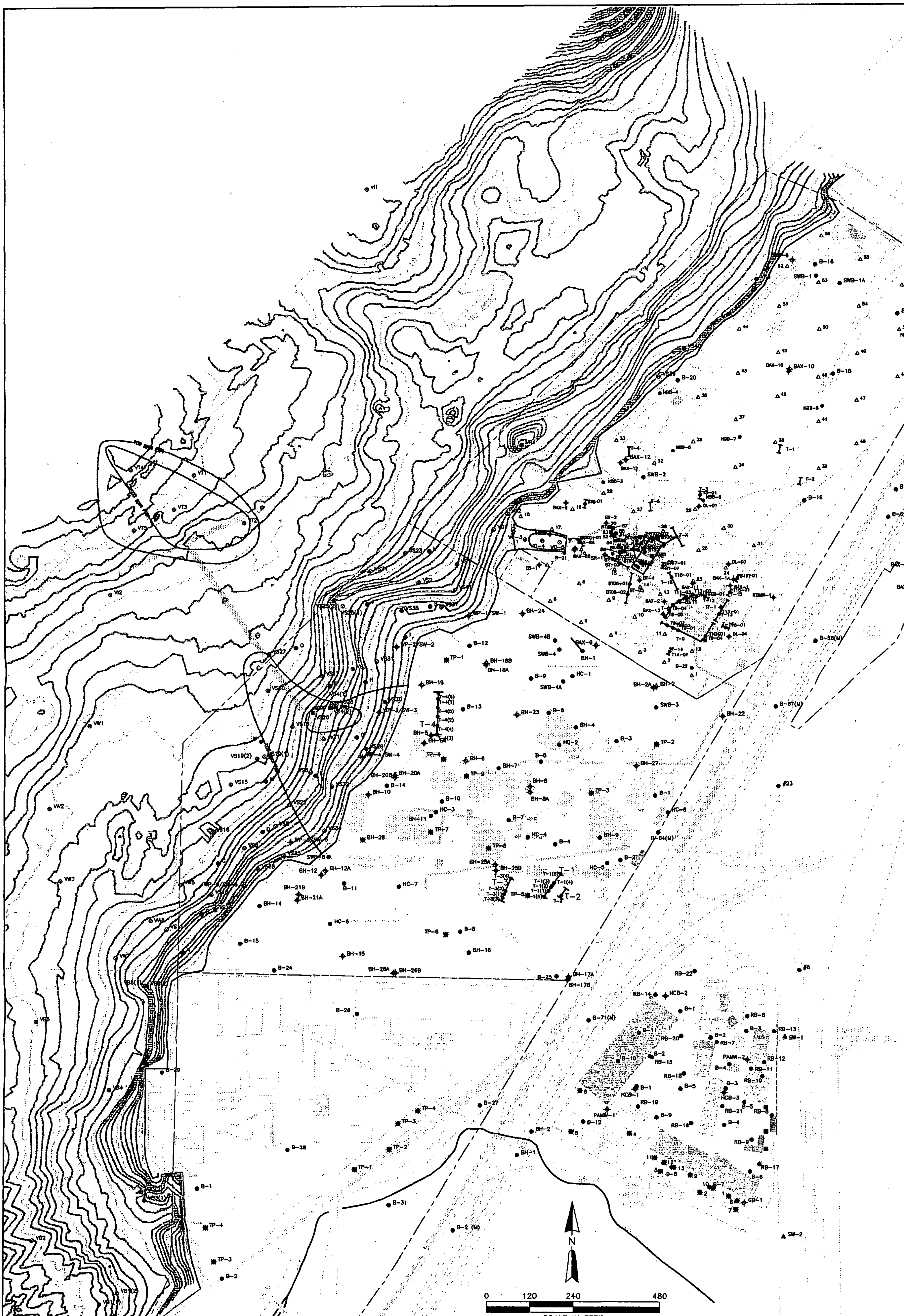

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BATHYMETRIC CONTOURS OF ADJACENT LAKE FLOOR

RETEC REMEDIATION TECHNOLOGIES INC

DRAWING NO. FIGURE 2-4

REV. 0

Besides the logs and utility lines, the survey identified other debris including concrete anchors and metal debris. The amount of this debris was limited compared to the log debris. Approximately 130 pilings and dolphins were mapped within the Harbor Lease areas during the site survey, excluding the pilings associated with the Quendall Barge Dock and the Barbee Mill dock and mill building. The pilings and dolphins are located in all areas of the site in water depths ranging from less than 5 ft up to 30 ft.

2.2.2 Sediment Particle Size

A sediment profile imaging (SPI) survey provided generic information about the particle size distribution for the sediments. In general, the lake bottom sediments consisted of a fine silt/mud with a small particle size. However, there were several areas in which a more sandy bottom was evident in the SPI images, including:

- Mouth of May Creek
- Quendall Sand Spit
- Quendall sediments near the outer harbor line
- Sediments north of the utility corridors
- Sediments in the Baxter sand mound
- Sediments at the northern edge of the Baxter outer harbor area

During the beach surveys, additional areas of sandy sediments were noted. These included two short stretches of beach along the Quendall terminals property. One of these was located north of the former mouth of May Creek, just north of the Quendall log dump. The second was located just south of the Quendall sand spit. In this latter location, the beach was generally covered with a thick layer of wood waste and bark, but sand was noted at water depths ranging from 1 to 4 ft below the low water line.

2.2.3 Sediment Infauna, Macrofauna and Flora

During the SPI survey, video transects, and during sediment grab sampling, observations were made regarding sediment-dwelling organisms, macrofauna and flora. These observations were qualitative in nature, as they were collected inadvertently during sampling for other parameters. Sediment-dwelling infauna noted during sampling included the following:

- Chironomids
- Amphipods
- Oligochetes
- Annelids

CP 000966

Macrofauna noted during video transects and grab sampling included the following:

- Freshwater clams and mussels
- Crayfish
- Smallmouth bass
- Sculpin
- Perch
- Sockeye salmon

The crayfish, sculpin and perch were noted in and around wood debris, including some individuals which had created burrows or dens in the debris. Bass were noted during video transects near one of the dolphins from the former Quendall T-Dock. One juvenile smallmouth bass (2 inches long) was retrieved in a Van Veen grab sample. A small crayfish and many of the clams and mussels were retrieved in this manner as well.

Areas of milfoil were also noted in the side-scan sonar and video surveys, with dense milfoil areas characterized by water depths between 5 and 15 ft. Milfoil was generally absent adjacent to Barbee Mill, possibly due to shading provided by log bundles and log rafts stored in the inner harbor.

2.3 Geotechnical Issues

2.3.1 Design Concerns

Seven boreholes were advanced within the project area to depths between 120 and 150 ft bgs to evaluate subsurface geologic conditions and to provide geotechnical recommendations for development of the site (Shannon & Wilson, 1997). Design concerns identified from this drilling program were liquefaction, settlement, and subsurface contamination.

The upper 50 to 60 ft of soil within the project area are loose and potentially susceptible to liquefaction during a strong earthquake. This liquefaction would result in loss of shear strength and the capacity of the soil to support structures on shallow foundations. This liquefaction could also result in lateral spreading of these soils on the order of 6 to 12 inches. Consolidation of near-surface peats and clays from placement of 10 to 15 ft fill upon this material would result in surface settlements of 1 to 3 ft. It is anticipated that this settlement would occur within the first two years following placement of the overlying fill. The structures' requirement for deep piles through contaminated areas may enhance vertical migration of dense non-aqueous phase liquids (DNAPLs) along the pilings. Restrictions on construction activities to prevent contamination migration to depth may include double casing and grouting systems incorporated with the pilings and adjustments to building locations to avoid areas of gross contamination.

2.3.2 Recommendations

Geotechnical recommendations made by Shannon & Wilson include the use of deep foundations, floor slab supports and clean sand and gravel fill. A driven pile foundation system using 18- or 24-inch-diameter concrete or steel piles to a maximum depth of 90 ft was recommended for the Quendall property, with lesser depths required elsewhere within the project area. Floor slabs for all buildings and garages were recommended to be structurally supported with driven pile foundations, and clean, free draining sand and gravel was recommended for use in future site filling.

2.4 Soil Quality

Numerous investigations of potential soil contamination within the Port Quendall project area have been performed, generating a large volume of geologic and chemical data. Comprehensive summaries of project area historical information, regulatory records and environmental data have been provided in two Draft Remedial Investigations (Woodward Clyde, 1990 and Hart Crowser, 1996). This existing data was incorporated with data collected by RETEC during the due diligence to develop an interpretation of upland soil conditions currently present at the project area.

2.4.1 Soil Data Sources

Nearly 50 environmental and/or geotechnical studies are known to exist for properties located within the project area, dating from 1963 to the present. Data from these studies provided project area subsurface geological information as well as soil, groundwater, and vapor analytical data. Figures showing data locations, depths, and the results used to determine impacted soil volume outlines within the project area were provided in the *Upland Constituents Memorandum* (RETEC, 1997f).

Soil analytical data for the project area include 166 upland soil sampling locations where polynuclear aromatic hydrocarbons (PAH) data were obtained by either laboratory analyses using EPA Method 8270, field screening by gas chromatography (GC) Screen, Fluorescence Screen, or Immunoassay analytical techniques. At several locations, multiple analytical techniques were used for the same sample, allowing for a comparison of results between methods; this issue is discussed in Section 2.4.2 of this document. Soil samples for PAH analyses were collected at multiple depths between the surface and a maximum sample depth of 39.5 ft bgs.

There were 123 upland soil sampling locations where PCP data were obtained by either EPA Method 8270, EPA Method 8040 or GC Screen. Sample depths ranged from the surface to 33.0 ft bgs.

There were 34 upland soil sampling locations where benzene, toluene, ethylbenzene and xylene (BTEX) data were obtained by EPA Method 8020, EPA Method 8040 or GC Screen, with sampling depths ranging between the surface and 33.5 ft bgs. As all soil samples with detectable BTEX concentrations were located within PAH-impacted areas and BTEX levels were relatively low, BTEX constituents were not considered further in determining the areas requiring soil treatment.

There were 19 sample locations within the project area where soil metals data were obtained by EPA Method 6010. Soil samples were collected at multiple depths between the surface and 7.5 ft bgs. Detected metals in soil at the Quendall and Baxter properties were at or below regulatory criteria or background levels reported by Ecology's Natural Background Soil Metals Concentrations in Washington State, and were not considered further.

Much of the interpretation of soil conditions was made from information taken from geotechnical and environmental soil boring logs, monitoring well geologic logs, and test pit soil descriptions. These logs and field notes also provided information concerning field observations of soil and/or groundwater contamination and the presence of buried structures and debris remaining from past site activities.

2.4.2 Data Validity

Different types of data were available for use in delineating impacted soil zones within the project area. These were:

- Quantitative data developed using EPA Method laboratory analytical techniques such as EPA Method 8020
- Quantitative field screening methods such as immunoassay and absorbence which generally provide less accurate soil concentrations
- Areas of known groundwater contamination and/or DNAPL accumulation in groundwater wells

- Qualitative visual observations of soil conditions made by geologists logging soil and monitoring well borings and test pits

- Qualitative historical information taken from documents describing past activities and practices at industrial facilities within the project area

A comparison of PAH results for those soil samples which were analyzed by both laboratory EPA Method 8270 and field screening techniques indicated that field screening results tended to overestimate soil concentrations by approximately a factor of 10. However, there was an insufficient number of data points in this comparison for a reliable correlation curve to be developed, and the samples which had multiple PAH analyses tended to have relatively low laboratory-measured concentrations. For the purposes of delineating impacted soil areas, laboratory and field screening data were considered equally valid, although a wide degree of variability is known to exist between these data types.

Field records concerning the relationship between sampling locations and visible DNAPL in soil were also taken into account, as analytical sampling points were often selected above and below soil layers with visible product. Relying only on the resultant quantitative data would underestimate the extent of soil contamination present. Notations made in field notebooks, test pit descriptions and geologic logs describing the presence and location of product, soil staining, sheen and odor were included in impacted soil zone delineation. For the purposes of determining impacted soil areas, field notations of visible product in soil were included as DNAPL data points, and notations of soil staining were considered to have a PAH concentration of greater than 1,000 mg/kg.

The location of former refinery and process area facilities and historical accounts of site activities and practices were also taken into account in soil zone determinations. In some areas, historical records indicated that soil contamination was likely, but soil sampling points were sparse.

2.4.3 Impacted Soil Zone Determination

Using the field and laboratory analytical data as well as field observations of soil quality and historical accounts, areas of impacted soil within the project area were outlined. These areas were categorized as:

- Baxter Lagoon
- Nearshore dense non-aqueous phase liquids (DNAPL)
- Farshore DNAPL
- Total PAH (TPAH)concentrations exceeding 1,000 mg/kg

CP 000970

- PCP concentrations above 100 mg/kg
- Carcinogenic PAH (CPAH) concentrations above 1.0 mg/kg

Probable impacted soil zones for the project area are shown on Figure 2-5. These probable areas are classified by their location or historical use as: Baxter Lagoon, Baxter Nearshore and Farshore Process Areas, Quendall Pond, former May Creek Channel, Still House and the North Sump. Only areal extent is shown on these figures, but each soil zone has a third dimension extending to various depths.

Baxter Lagoon

Potential RCRA hazardous wastes at the project area are limited to wastewater treatment sludges possibly present in the former runoff pond on the J. H. Baxter property. The J. H. Baxter Lagoon contains an estimated 500 cy of potentially Listed Hazardous Waste sludge resulting from former industrial processes at the wood treating facility. In addition, there may be impacted soils beneath this sludge layer.

Nearshore DNAPL

The only area included in nearshore DNAPL is Quendall Pond (Figure 2-5). This is considered a high priority area due to the proximity of DNAPL in this area to potential aquatic receptors in Lake Washington.

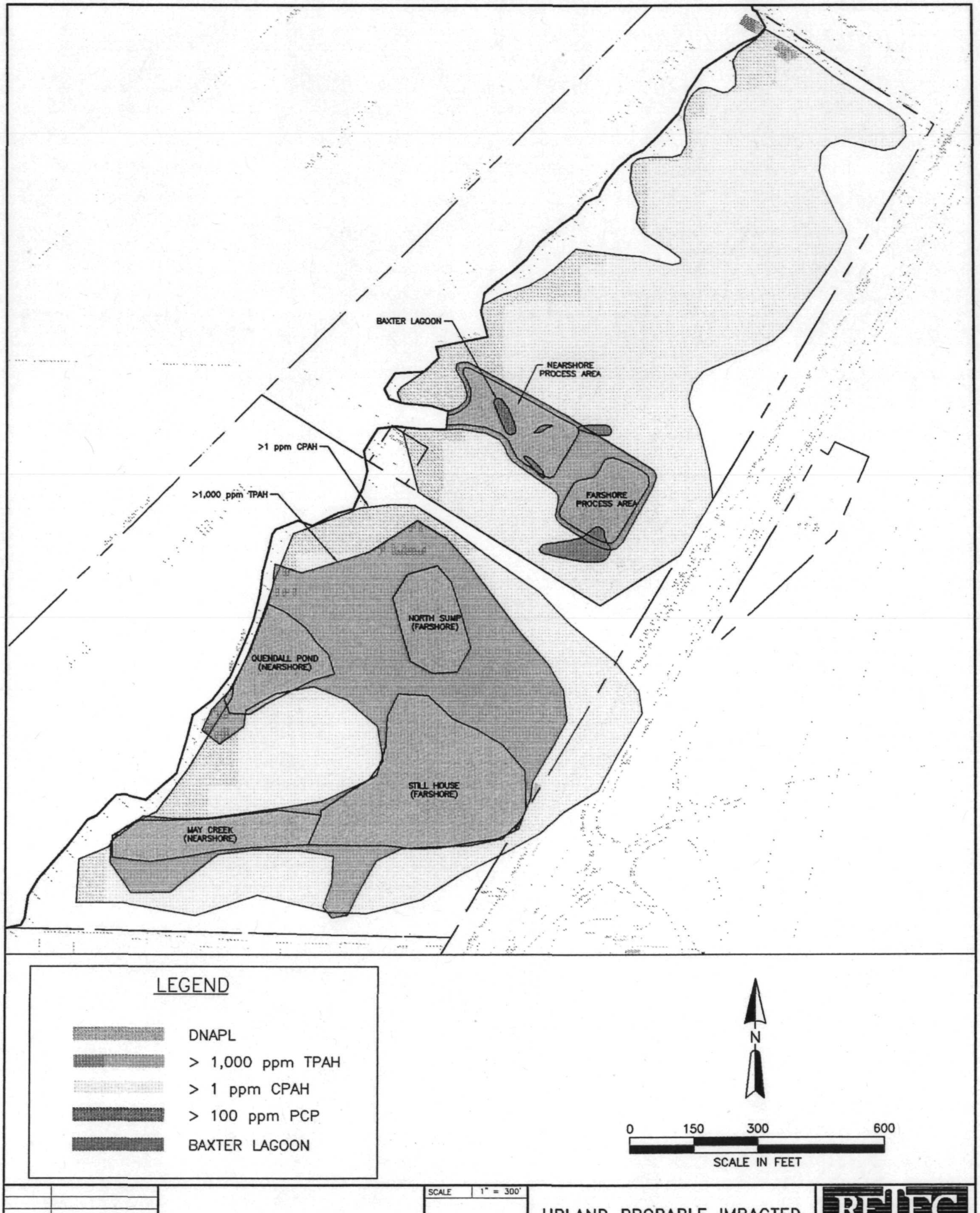
Farshore DNAPL

Other areas contain mobile DNAPL that has not impacted and does not appear likely to impact sediment or surface water quality. These areas include the former May Creek Channel, the Quendall North Sump, the Quendall Still House and the Nearshore and Farshore Baxter Process Areas (Figure 2-5). These are considered to have high priority due to the presence of DNAPL and associated contaminants. However, they are distanced from potential aquatic receptors.

TPAH Above 1,000 mg/kg

These impacted soil areas are those that are considered unlikely to have mobile DNAPL, but have TPAH soil concentrations above 1,000 mg/kg. These areas are located on both Quendall and Baxter and generally encompass the DNAPL areas (Figure 2-5). Though these areas could potentially impact groundwater quality via soil leaching, they are considered to have lower priority, as there is no DNAPL and they are generally removed from potential aquatic receptors.

CP 000971



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3-2438-612

SCALE 1" = 300'

CAD FILE 24385199

UPLAND PROBABLE IMPACTED SOIL AREAS

RETEC REMEDIATION TECHNOLOGIES INC

DRAWING NO. FIGURE 2-5 REV. 0

CP 000972

PCP Above 100 mg/kg

PCP areas encompass 385 cy of soil which have confirmed PCP concentrations above 100 mg/kg. These are located only on the Baxter property (Figure 2-5). Although these impacted soil areas could potentially impact groundwater quality via soil leaching, they are considered to have lower priority, as there is no DNAPL and they are generally removed from potential aquatic receptors.

CPAH Above 1.0 mg/kg

These impacted soil areas are those with CPAH concentrations above 1.0 mg/kg. These areas extend over most of the Quendall, Baxter, and North Baxter Properties and are considered to have a lower priority as they pose no threat to groundwater; however, they may constitute a direct contact concern.

2.4.4 Impacted Soil Volume Calculations

For each impacted soil zone, the volume of impacted soil was calculated by designating the depth range of impacted soil at points along the perimeter and within the area. The depth range for each zone was estimated using all available data, and were not uniform. Selected points with the top and bottom elevation of the impacted zone within the perimeter and on the boundary were digitized into a three-dimensional AutoCAD program, which then calculated soil volumes.

These calculations were performed for DNAPL and TPAH above 1,000 mg/kg zones, as well as the Baxter Lagoon, PCP above 100 mg/kg, and CPAH above 1.0 mg/kg zones. The volume of impacted soil present in the Baxter Lagoon was estimated at 500 cy, while the four PCP areas totaled 385 cy. As the PCP above 100 mg/kg areas are primarily situated within TPAH-impacted zones of the Baxter property, the PCP zones are included with TPAH designations. All other estimated volumes of impacted soil and clean overburden for each soil classification areas are presented in Table 2-1.

In order to evaluate the accuracy of the impacted soil volumes, probable and possible soil volumes were generated for the Quendall Property. This evaluation was originally presented in the *Upland Constituents Memorandum* (RETEC, 1997f). This evaluation indicated that the DNAPL soil zones could be up to 50 percent greater than used in preparing this FS. The TPAH above 1,000 mg/kg could be up to 60 percent greater. These volume increases would proportionately change impacted and overburden soil volumes.

CP 000973

2.4.5 Other Soil Issues

Soil and groundwater sampling performed at Pan Abode as part of the PQC due diligence is described in detail in the *Soil and Groundwater Analytical Results for Pan Abode Report* (RETEC, 1997h), which also includes references to previous environmental and geotechnical investigations at the property. A slag-type material used as fill was noted in geoprobe borings and test pits, as shown on Figure 2-6. Data for underlying soil and groundwater did not show any adverse impacts from this material.

2.5 Groundwater Quality

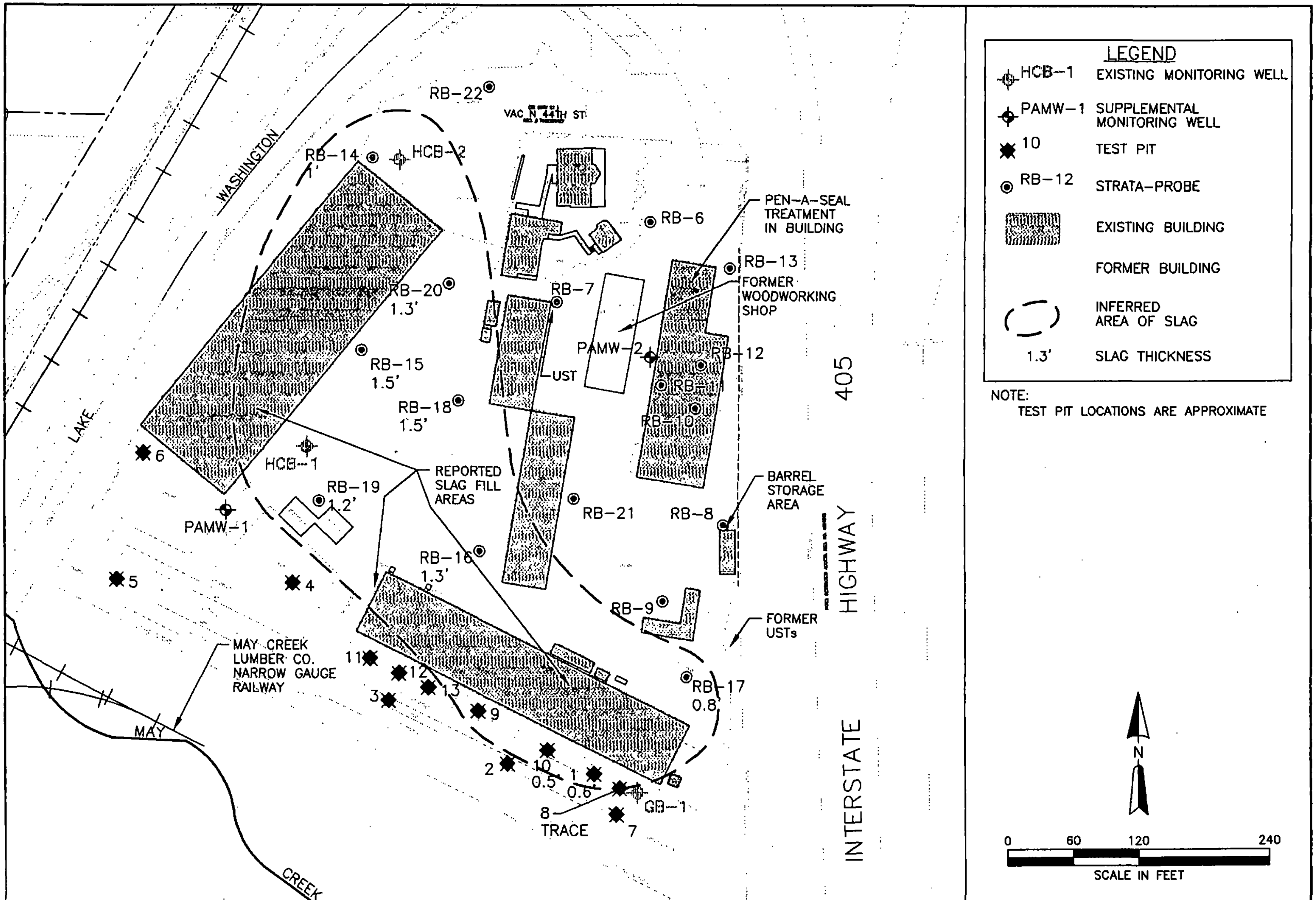
Past activities at the project area have resulted in impacts to groundwater quality. Chemical compounds detected in groundwater in the study area include PAHs, PCP, and BTEX compounds. Saturated zone DNAPL is also discussed in this section.

The detected compounds were evaluated based on maximum observed concentration, frequency of detection, exceedance of applicable surface water criteria, and the cancer slope factor for carcinogens. Based on this analysis, it was proposed that transport evaluations will be limited to benzene, naphthalene, and chrysene.

Table 2-1 Estimated Impacted Soil and Clean Overburden Volumes

Impacted Area	Impacted Soil Volume (cy)	Overburden Soil Volume (cy)
DNAPL Areas		
Baxter Lagoon	500	0
Quendall Pond	14,900	6,910
Former May Creek	8,210	15,210
Baxter Nearshore	13,620	0
North Sump	5,930	13,740
Still House	20,010	22,960
Baxter Farshore	4,800	0
>1,000 mg/kg TPAH	147,180	96,800
>1 mg/kg CPAH	426,470	20,900

CP 000974



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SCALE 1" = 120'

CAD FILE 2438S200

INFERRED SLAG LOCATIONS, AND THICKNESS AT THE PAN ABODE PROPERTY

RETEC
REMEDIATION TECHNOLOGIES INC

DRAWING NO. FIGURE 2-6 REV. 0

CP 000975

3 Cleanup Standards

Reserved.

4 Remedial Technologies

The intent of this section is to briefly describe a limited number of technologies that are potentially applicable for the Port Quendall development. Certain technologies will be assumed for describing and costing remedial alternatives later in this FS. This selection does not preclude the use of other applicable technologies for site remediation.

4.1 Technologies for Remediation of Soil

This section provides an evaluation of several soil remedial technologies under consideration for treatment of impacted soil at the Port Quendall project area. These remedial technologies were selected to address interpreted upland soil conditions previously described in the *Upland Constituents Memorandum* (RETEC, 1997f) and which are summarized in Section 2 of this FS.

Soil at the Port Quendall project area is impacted with PAH, CPAH, and PCP. DNAPLs have been observed in some wells, soil borings, and test pits located in areas associated with the former tar refinery and wood treating facilities. To provide a means of analyzing the relationship between practicability and the extent of contaminant destruction achieved for each remedy, categories of contaminated soils were established as follows:

- Potential hazardous waste (Baxter Lagoon)
- Nearshore DNAPL (Quendall Pond)
- Farshore DNAPL
- TPAH above 1,000 mg/kg
- PCP above 100 mg/kg
- CPAH above 1 mg/kg

The potential soil remedial technologies discussed in this section have been selected to address the soil conditions present within these impacted soil zones. The ultimate cleanup action plan for the project area may include a combination of several different soil remedial technologies.

Soil remedial technologies that are regionally available and commonly used for cleanup of soil containing PAH and PCP are summarized in Table 4-1. This list has been condensed based partly on the Environmental Protection Agency (EPA) *Presumptive Remedies for Soils, Sediments and Sludges at Wood Treater Sites* (EPA, 1995). These technologies are listed in order of preference outlined in the Ecology MTCA Section 173-340-360.

CP 001001

Excavation of contaminated soil is included as the initial element of several remedial alternatives for the site. This excavation would require a planned sequence for control of surface and groundwater, segregation and containment of materials, stockpiling for treatment or other disposition, and excavation backfilling and regrading. These activities may take place for several of the remedial technologies discussed. For the unit cost comparisons in this section, specific costs for each remedial technology apply to that soil treatment option only, and do not include costs for excavation and stockpiling, dewatering and water disposal, backfilling and compaction, or other related activities.

Table 4-1 Potential Remedial Technologies for Impacted Soil

I. **Reuse and Recycling - none considered**

II. **Destruction/Detoxification**
   a. Thermal desorption
   b. Incineration (of LDR-listed hazardous waste)
   c. Bioremediation

III. **Separation - none considered**

IV. **Immobilization**
   a. Stabilization

V. **Disposal**
   a. Landfilling (of non-LDR-listed hazardous waste)

VI. **Containment**
   a. Hard/Soft capping
   b. Double-cased or pre-grouted pilings

VII. **Institutional Controls and Monitoring**

The costs for the aforementioned tasks associated with some remedial technologies are provided below:

• Excavation and Stockpiling	$10 to $15 per ton
• Dewatering and Water Treatment/Disposal	$10 to $20 per ton
• Backfilling and Compaction	$ 5 to $10 per ton

These costs assume an excavation volume of at least 10,000 tons, such that some economies of scale are achieved. For comparison purposes, we have also assumed

CP 001002

that any excavation on the Port Quendall property will require dewatering with water treatment and disposal.

4.1.1 Destruction/Detoxification

Thermal Desorption

Thermal desorption is a proven and rapid means for treating soil contaminated with petroleum hydrocarbons, PAHs, CPAHs and creosote. This technology uses ambient air, heat, and mechanical agitation to separate volatile and semivolatile organic contaminants from excavated soils. Contaminated soil is heated to temperatures ranging from 400°F to 1,000°F, thereby expelling water and volatile and semivolatile contaminants. Volatilized contaminants are typically thermally oxidized in a secondary treatment chamber. Other less common secondary treatment processes either condense the compounds for disposal or capture them on carbon adsorption beds. Mobile thermal desorption units are in the market place and have been successfully used at wood-treating sites. The nearest fixed-base thermal desorption facility to the project area is operated by TPS, Inc., and is located in Tacoma. CSR Associated also operates a fixed-base thermal desorption facility in Everett.

Project area soils to be treated by thermal desorption would be excavated and stockpiled on site in a managed area prior to treatment. This action would provide immediate and long-term reduction in the potential for further migration of the contaminants in the soil. Thermal desorption would also offer a permanent reduction in toxicity, mobility and volume of contaminated soil at the site. If on-site thermal desorption is used, treated soil may be immediately available for use as backfill. If off-site thermal desorption were used, transportation back to the site of treated or other clean fill would be required for backfilling the excavations.

Sufficient space is available at the site to implement on-site thermal treatment. Debris and oversized objects could be used for backfill if determined to be uncontaminated. A typical soil feed rate for an on-site thermal unit is 20 to 90 tons per hour. Costs for treatment of large volumes of contaminated soil using an on-site thermal unit are estimated at $40 to $50 per ton. Including excavation-related costs, the cost of on-site thermal treatment would be approximately $65 to $95 per ton.

Off-site thermal treatment would also require a soil stockpiling and loadout area, as well as an additional stockpile area for clean imported fill material. Transportation of excavated untreated soils and return fill would require use of public streets. Haul roads and truck traffic patterns for the export and import of soil would have to be established and maintained. Cost for treatment by the TPS facility is estimated at $40 to $50 per ton, including the cost of trucking the contaminated material to Tacoma and returning the treated soil to the site to be used as fill. Including excavation-related costs, the cost of off-site thermal treatment would be approximately $65 to $95 per ton.

Incineration

Treatment by incineration is a proven technology for sludges and liquid wastes and has been demonstrated effective for organic constituents in soil. Parameters affecting the incineration process include moisture content and heating value of the materials to be incinerated. The initial step in the incineration process would be soil excavation, which would provide an immediate and permanent reduction in the volume of contamination present at the site.

Incineration can be performed at either an off-site commercial facility or on-site with a permitted mobile incinerator. The only material at the project area considered for incineration is potentially listed waste present in the Baxter Lagoon. The only material from the site that may be incinerated is land disposal restricted (K001) listed hazardous waste. Due to the small volume of this material, it would not be cost effective to mobilize an on-site incineration unit to the site. Off-site incineration involves transporting the contaminated soils to a permitted hazardous waste incineration facility, incinerating the soil and disposing the ash.

Off-site incineration would require similar soil stockpiling and truck patterns previously described for thermal desorption. The closest permitted incinerator is located in Salt Lake City, Utah and is operated by Laidlaw. The cost of off-site commercial incineration ranges from $750 to $1,000 per ton of soil, including disposal of residual ash and excavation-related costs.

Bioremediation

Bioremediation has been used at numerous wood treating sites across the country to detoxify soil contaminated with PAHs and PCP. The technology has not been used in Washington for creosote- or coal tar-contaminated soils. Reported destruction efficiencies range from 50 to more than 90 percent. The most common application is land treatment, which involves spreading a lift of soil over a prepared bed and providing adequate moisture, frequent tilling and nutrients. Approximately 1,000 to 2,000 cy per acre can be processed using conventional land treatment techniques. In general, treatment takes 6 months to 1 year, depending on climatic conditions and the soil/contaminant matrix.

CP 001004

Costs range from $30 to $40 per cy, depending on the requirements for the construction of the prepared bed and stormwater handling. This technology is not considered applicable to the PQC project because of timing and space considerations.

4.1.2 Stabilization/Solidification-Shallow Soil Mixing

Stabilization/solidification of contaminated soil using additive materials such as cement, fly ash, and lime has been demonstrated effective in eliminating mobility and leachability of hydrocarbons. In most cases, design level laboratory testing is required to determine the optimal mixing ratios of soil and additives. Stabilization can be completed either *in situ* or *ex situ*.

In situ minimizes material handling costs and is the preferred approach for the site. The *in-situ* soil treatment technology involves micro-encapsulation of contaminated soil in a concrete matrix. This method was initially developed for civil engineering applications to provide additional bearing capacity for soft soils. The appropriate slurry or dry mix is injected directly into the soil under high pressure and mixed *in situ* with the contaminated soil by a tracked unit which provides rotary mixing. Soils are mixed with a single-blade auger or with a combination of augers ranging from 3 to 12 ft in diameter. Mixing can be accomplished to depths exceeding 100 ft using this method.

The encapsulation of the contaminated soil reduces toxicity and mobility, but does not reduce contaminant volume. The encapsulated material also acts as a barrier to groundwater movement, and soil mixing could be implemented in conjunction with other physical containment barriers ultimately selected for the site.

A significant advantage to stabilization/solidification soil technologies is the elimination of the requirement for excavating and treating contaminated soil. This greatly reduces the exposure risk of site workers and nearby residents, and eliminates the need for stockpile areas, loadout areas and heavy truck traffic on public roadways. Costs for shallow (less than 40 ft) soil mixing range from $35 to $75 per ton, depending on depth and the slurry mix required for the site, with placement rates typically 40 to 60 tons per hour for each mixing rig.

4.1.3 Disposal

Soils at the project site that are classified as containing a listed hazardous waste for which there are no land disposal restrictions in place could be excavated and transported to a permitted hazardous waste landfill for disposal. These materials may be generated from the tank farm or butt tank areas of the Baxter site.

Hazardous materials disposed in a Subtitle C Resource Conservation and Recovery Act (RCRA)-approved facility would be prevented from contaminating the environment by placement in a secure, lined landfill. RCRA landfills are equipped with liners and are capped to prevent off-site migration of contaminants. Monitoring for leaks is also implemented to provide early detection of leachate releases so that actions may be taken to safeguard human health and the environment.

Disposal provides no reduction in the mobility, toxicity, or volume of hazardous material. However, the risk of exposure to the contaminants at the site would be immediately reduced by the removal of these soils. The potential for these soils to act as a continuing source of contamination to the subsurface would also be reduced. The potential for workers to be exposed to contaminants via fugitive dust emissions and the potential for off-site migration of contaminated soils via stormwater runoff exist during excavation of the soils.

Cost for disposal at a hazardous waste landfill ranges from $100 to $200 per ton of waste, including transportation, depending on the characteristics of the material and the amount requiring disposal. Including excavation-related costs, the cost of soil disposal at a Subtitle C landfill would be approximately $125 to $245 per ton.

4.1.4 Containment

Containment involves leaving the contaminated soil in place and designing a system that isolates the medium from direct contact and reduces the mobility of the contaminants. Containment technologies include surface capping and subsurface physical barriers such as sheet piles, HDPE liners or slurry walls to reduce contaminant migration.

Capping

This method limits human exposure to contaminants by direct contact and minimizes the transport of contaminants to groundwater by preventing recharge by rainfall. Potential capping materials at the project area could include "soft" caps, such as topsoil that may be underlain by compacted clay or synthetic liners; and "hard" caps, such as buildings and asphalt. Some form of cap maintenance is typically required to ensure that its integrity is not affected by site use or climate. Capping does not represent treatment, so toxicity, mobility and volume of contaminants would not be reduced by this technology. However, the potential for contaminant migration to occur is lessened due to the reduction in infiltration. Both hard and soft caps are easily implemented, at a cost estimated at $2 to $6 per square foot, not including maintenance costs.

Soil cover?

CP 001006

Double-cased or Pre-grouted Pilings

The potential need to install deep piles (80 to 90 ft) for building foundation structural support may require that a system be implemented to prevent DNAPL migration to depth along the exterior of the driven piles. A double-cased pile design would entail driving an oversize, open-end casing to a depth below the level of contamination, with the contaminated soil inside the casing then removed. The pile foundation would then be placed inside this casing and driven to the required depth. The annulus between the pile foundation and the outer casing would be grouted with a cement-bentonite slurry and the outer casing removed. The cement-bentonite slurry would provide the low-permeability barrier to DNAPL migration downward along the pile foundation.

overdesign

A pre-grouted piling system would consist of jet grouting performed at each pile location, with the grout material injected into the subsurface at high pressure to a depth below the contamination. The foundation piles would then be placed through this grout, with the grout acting as the low permeability barrier to downward migration. The cost to implement either of these additional measures to the piling structural support system is estimated at $60 to $70 per linear foot of piling. These costs will not be included in the FS but this technology may be implemented during site development if required due to the presence of residual DNAPL remains within the proposed development areas.

4.1.5 Institutional Controls and Monitoring

Institutional controls and monitoring are typical components of most cleanup remedies, ensuring that future actions at the site take into account remaining subsurface conditions. It is anticipated that institutional controls and monitoring will be a component of any remedial alternative selected for the site. The magnitude of the controls and intensity of the monitoring will be determined based on the remedial alternative selected.

4.2 Technologies for Remediation of Groundwater

The number of technologies to be evaluated in the PQC FS have been compressed due to the accelerated schedule. The remedial technologies for groundwater summarized in Table 4-2 are currently being considered.

4.2.1 Destruction/Detoxification

Groundwater Extraction, Treatment, and Discharge

Groundwater extraction at the Port Quendall site is currently intended as a backup measure to provide groundwater capture upgradient of a containment wall should *in-situ* treatment not achieve the required criteria at the point of compliance.

Table 4-2 Potential Remedial Technologies for Impacted Groundwater

I. **Reuse and Recycling - none considered**

II. **Destruction/Detoxification**
   a. Groundwater extraction, treatment, and discharge
   b. *In-situ* groundwater treatment
   c. Natural attenuation

III. **Separation**
   a. DNAPL recovery

IV. **Immobilization - none considered**

V. **Disposal - none considered**

VI. **Containment**
   a. Physical barriers

VII. **Institutional Controls and Monitoring**

Detoxification of contaminated groundwater is frequently performed by using pump-and-treat technology. This approach involves the use of extraction wells to pump groundwater from the subsurface where it is treated and ultimately discharged or reinjected to the groundwater. Pump-and-treat systems may be designed as the primary means of groundwater restoration, or may be configured to provide hydraulic containment near the downgradient edge of the plume of dissolved contaminants by removing and treating the contaminated portion of the aquifer flow.

Use of a groundwater extraction system will require treatment. Treatment technologies were selected based upon site knowledge and *Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites* (EPA, 1996) and include the following:

- Phase Separation
- Sequestering/Chelating/Complexing
- Precipitation
- Filtration
- Aerobic Biological Reactors

CP 001008

- Chemical or UV Oxidation
- Granular Activated Carbon Adsorption

Discharge alternatives include NPDES discharge to Lake Washington, re-injection to groundwater, and Metro discharge to the Renton POTW. Temporary Metro discharge permits for construction purposes typically are restricted to approximately 60 gallons per minute (gpm). More long-term discharges for groundwater treatment systems are typically restricted to 17 gpm although variances may be sought. Metro discharge criteria are typically more lenient than NPDES discharge or groundwater reinjection criteria.

Phase separation and filtration are assumed to be required for any groundwater treatment system. Precipitation or sequestering/chelating/complexing may be used to prevent inorganic deposits, particularly iron, and may also serve to limit biological growth related to those compounds. Biocides may also be introduced to prevent biological growth. Biological reactors and oxidation systems may be used to pretreat the water prior to polishing by carbon adsorption or they be used as stand alone treatment if discharge is to the Renton POTW. Carbon adsorption could be used for polishing of pretreated water, as mentioned above, or it could be used as a stand alone water treatment system. The use of carbon treatment would be required for NPDES discharge to Lake Washington or reinjection to groundwater. Estimated cost for a groundwater extraction system is $25,000 per well with $2,500 per well in annual operations and maintenance. The estimated cost for a 100-gpm water treatment system is $500,000 with $200,000 in annual operations and maintenance, not including any costs for discharge. For cost estimation purposes, we have assumed only carbon treatment prior to NPDES discharge. Biological reactors or oxidation systems will only be used should they provide a cost savings relative to carbon-only treatment.

In-situ Groundwater Treatment

It is anticipated that *in-situ* groundwater treatment will be performed under any remedial alternative that does not include excavation of all soil exceeding surface water protection standards. It is further anticipated that *in-situ* treatment will be combined with a containment wall so that treatment may be focused along the wall where flow paths converge prior to groundwater discharge to the lake.

In-situ air sparging is often an effective approach that combines air stripping in place with *in-situ* biodegradation. Air is injected into the groundwater, using compressed air in a well bore that contains a screened section below the water table (typical depths are approximately 10 ft below the water table). Where the contaminant is concentrated and particularly volatile (e.g., benzene, methane),

CP 001009

the potential for migration of vapors can necessitate combining air sparging with vacuum extraction in the vadose zone.

In-situ air sparging would elevate levels of dissolved oxygen in the formation and stimulate degradation of dissolved-phase constituents by native organisms present in the groundwater. Elevated dissolved oxygen levels would remain downgradient of the air sparging and would continue to stimulate biodegradation of constituents prior to discharge into Lake Washington.

Aeration would also raise the redox potential in the subsurface, encouraging oxidation, and therefore precipitation, of most dissolved metals (including arsenic). This would reduce dissolved metal concentrations in groundwater but, due to precipitate clogging of pore space, may also complicate the implementation of *in-situ* treatment. The cost of air sparging is estimated at $150,000 to $350,000 per acre of sparged treatment zone.

Natural Attenuation

Natural attenuation can be an effective means for containment and eventual cleanup of contaminated groundwater. Monitoring is required to confirm that natural attenuation is adequately protective. Several field-scale results have demonstrated that natural attenuation occurs, and that it can be protective. Natural attenuation rates for benzene and related volatile organic aromatic compounds have been measured at several sites, and the rates are generally in the range of 0.5 to 1.0 percent per day (Chiang *et al.*, 1993). These contaminants are the predominant groundwater concern at the site.

There is also an increasing understanding of the types of information needed to demonstrate and verify that natural attenuation is occurring. Plumes undergoing natural attenuation generally exhibit zones of anaerobiosis near the source area, and eventual reappearance of dissolved oxygen at the plume boundaries. Such sites also often show depletion of other oxidants near the anaerobic areas (nitrate and sulfate, for example), increased concentrations of PAH or other specific compound degrading bacteria in areas with dissolved oxygen concentrations in the range of 0.5 to 2 mg/L, and losses of the most degradable constituents earliest in the plume (Borden *et al.*, 1995).

Limitations on natural attenuation are similar to those for any other bioremediation process. The contaminants of concern must be sufficiently biodegradable, and the environmental conditions must be conducive to biological activity (e.g., adequate pH, nutrients, and a lack of chemical toxicity). As described in Section 5.4, the potential applicability of natural attenuation to the Port Quendall redevelopment project was evaluated in groundwater modeling and treatability work performed by RETEC. Based on the conservative assumptions used in the modeling work, natural attenuation was assumed to have limited applicability at the Quendall site for contamination from shoreline or nearshore source areas.

4.2.2 Reuse/Recycling—DNAPL Recovery

There are three areas at the Quendall Terminals property where DNAPL has been detected adjacent to or past the current Lake Washington shoreline. These areas include the former May Creek channel, the Quendall Pond area and the North Sump. These areas are discussed in Section 2. Based on the depth and location of the detected DNAPL and the bathymetry of the lake bottom, the DNAPL in the Quendall Pond area currently has the potential to impact sediment quality in the lake. Migration from the former May Creek channel does not appear to have reached the lake shoreline. Migrating DNAPL from the North Sump has been limited to depths sufficiently below the sediment mud line (15 feet) to make sediment impacts unlikely.

DNAPL recovery tests were performed by Woodward Clyde at BH-5 (Quendall Pond) and BH-21A (former May Creek channel). DNAPL in BH-21A recovered to full thickness (5 to 6 ft) in approximately 16 hours. Recovery of DNAPL in BH-5 was substantially slower. However, based on observations during sediment sampling and evidence of sediment impacts, it would appear that more mobile DNAPL exists at Quendall Pond. In addition, due to the distance between the detected offshore DNAPL deposits at boring VS-2 and the presumed DNAPL source area at the North Sump, it would appear that DNAPL in the North Sump area is also mobile. stretch

The most effective method for recovering DNAPL, that does not involve extensive groundwater extraction, is to install subsurface trenches that intercept the various lenses of migrating DNAPL. A perforated HDPE DNAPL collection line is placed in the bottom of the trench and the line is connected to a recovery sump. The trench is then backfilled with a coarse grained matrix. This matrix is designed to prevent clogging by native soil or piping of native soil. The trenches in each location would be installed to a depth of 20 to 25 ft. These trenches would be installed using bioslurry techniques, trench boxes, or using specialized trenching equipment. The approximate cost for installing a DNAPL recovery trench is $30 to $50 per square foot. Additional costs would be incurred for pumping equipment, piping, and operations and maintenance.

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4.2.3 Containment—Physical Barriers

Physical containment is anticipated to be an integral part of any remedial alternative that does not include treatment of all soil that exceeds surface water protection standards. This physical containment wall will likely be placed upland or nearshore along most of the Quendall Terminals property shoreline. A variety of construction materials and installation techniques are available for physical containment walls. For the Port Quendall project we will focus on slurry walls, steel sheet piles, and HDPE sheet piles. Should *in-situ* soil mixing be used for soil treatment, this technique may also be considered for physical containment wall installation.

Physical containment will prevent lateral migration of DNAPL towards the lake and may assist in the containment and treatment of groundwater. The wall may be installed with gates at the top or bottom that would allow controlled discharge of perched groundwater (i.e., water from drainage systems above an impermeable cap). Installation of these gates would be difficult using the slurry wall alternative. Installation of the slurry wall may also be difficult if the wall is to be placed in a nearshore fill that is comprised of uncompacted soil placed in the lake. Slurry walls are typically 3 to 4 ft thick and have a hydraulic conductivity of 10^{-7} to 10^{-9} cm per second. Conductivities vary depending on the type and amount of admixtures and the characteristics of the excavated soil. These admixtures include bentonite, cement, fly ash, and attapulgite. Slurry walls can be installed to depths of up to 80 ft at a cost of $7 to $12 per square foot.

Steel sheet piles provide better structural support than slurry walls. The principal technical concern with steel sheet piles is the amount of leakage that may occur at the interlocks. A field test using hot rolled steel piles with conventional unsealed joints (Bethlehem Steel PZ22) indicated a hydraulic conductivity of 1.5 to 5×10^{-7} cm per second (Starr, 1992). This rate may be expected to decrease as the joints corrode and become clogged with silt. Steel sheet piles can be installed at a cost of $20 to $30 per square foot.

HDPE piles can reduce overall seepage rates. Tests on HDPE sheet pile interlocks indicate that the seepage rate varies from 6×10^{-8} to 3.3×10^{-6} gpm per foot of interlock (GeoSyntec, 1993). For a 30-foot-deep, 1,000-foot-long wall, the total seepage rate would be approximately 4.5×10^{-4} to 2.5×10^{-2} gpm. This converts to a hydraulic conductivity of 1×10^{-9} to 6×10^{-8} cm per second. The primary concern regarding HDPE sheet piles is whether they can be installed in dense soil and the high cost relative to slurry wall and steel sheet pile walls. HDPE sheet piles can be installed at a cost of $15 to $25 per square foot. contradicts above

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4.2.4 Institutional Controls and Monitoring

Institutional controls and monitoring will be an essential feature of any remedial alternative for the site. Long-term monitoring of groundwater will be required for any *in-situ* treatment option.

Property deeds could be restricted or have deed notices imposed to prevent any development of groundwater for drinking purposes within the affected portion of the site. Monitoring of groundwater quality would be conducted in conjunction with other remedial actions to track the composition of groundwater and ensure adequate performance of in-place remedial systems or the effectiveness of natural attenuation.

4.3 Technologies For Remediation of Sediment

This section addresses the technologies that can be used to implement remedial alternatives for the Port Quendall development and it presents a synopsis of a detailed analysis of technologies presented in the *Sediment Remedial Technologies Memorandum* dated June 23, 1997.

This section is limited to removal or isolation technologies for the in-water construction activities. Final treatment of sediments that have been removed, transported upland, and de-watered will be the same as that described for soil technologies.

Sediment technologies screened for use at the Port Quendall site are summarized in Table 4-3.

4.3.1 Dredge and Removal

The *Sediment Technologies Memorandum* presented three basic options for sediment removal. These are:

- *Mechanical Dredging.* Mechanical dredges remove sediment by applying mechanical force to dislodge and remove the dredged material. A typical mechanical dredge consists of a suspended or manipulated bucket lowered to the bottom that "bites" the dredge material and raises it to the surface.

Table 4-3 Summary of Screened Remedial Technologies

Media	Technology

Soil/Sediment	**Excavation**
	    Thermal Treatment
	    Incineration (K001 wastes)
	    Subtitle C Landfilling (F-wastes)
	***In-Situ* Soil Mixing**
	Bioremediation
	Capping—Soil
	    Asphalt Concrete Pavement
	    Synthetic Liners
	    Clean Fill
	Capping—Sediment
	    Full Cap (3-ft clean fill)
	    Enhanced Natural Recovery
	Double-Cased Piles
	Institutional Controls

Groundwater	**Biosparging**
	Pump-and-Treat
	Physical Containment
	    Slurry Wall
	    Steel Sheet Piles
	    HDPE Sheet Piles
	Passive DNAPL Recovery
	    Trenches
	    Wells
	Institutional Controls

Water Treatment	**Phase Separation**
	    Oil/Water Separation
	    Induced or Dissolved-Air Flotation
	Physical Treatment
	    Sedimentation—Sediment Dewatering Ponds
	    Coagulation/Flocculation
	    Sequestering/Chelating/Complexing
	    Filtration
	Biological Treatment—Aerobic
	Chemical Treatment—Chemical or UV Oxidation
	GAC Adsorption—1.24 pounds per 1,000 gallons

Dredging	**Hydraulic**
	    Cutterhead
	Mechanical
	    Cable Arm
	Excavation

NOTE:
Bold - Technology used in cost estimating.

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- *Excavators.* This is a sub-set of mechanical dredges which includes the backhoe and loader, both of which are limited in reach capability. Special closing buckets are available to reduce sediment losses and entrained water during excavation. Excavators are usually applied to dry or shallow water situations that can be accessed from shore-based or limited-draft floating equipment.

- *Hydraulic Dredging.* Hydraulic dredges remove and transport dredged materials as a pumped sediment-water slurry. The sediment is dislodged by mechanical agitation (e.g., cutterhead, auger, or high-pressure water jets), and then pumped to either a waiting barge or to an on-land dewatering facility.

Mechanical and Excavating Removal

Mechanical dredges are analogous to the familiar upland excavation equipment such as backhoes. While there are a number of different design styles, the mechanical dredge is basically a suspended bucket that grabs discrete volumes or sediment and raises it to the surface. The dredged material is then deposited in a haul barge or other contained conveyance for transport and rehandling to final disposition. Under suitable digging conditions, mechanical dredges are capable of removing dredged material at near *in-situ* densities, with almost no additional water entrainment in the dredged mass and little free water in the filled bucket. This low water content is highly important if dewatering is required for ultimate sediment disposal. Mechanical dredges provide one of the few effective methods for removing large debris.

Mechanical dredging is applicable to all the sediment remedial options, including wood waste removal. For the offshore removal of wood waste and PAH-contaminated sediments at T-Dock and Quendall Nearshore, an environmental clamshell type dredge would be employed. For nearshore excavation at Baxter Cove, or in the Full Seep and Partial Seep removal option, land-based backhoes would employed after placing sheet piles or coffer dams, and dewatering the site.

To limit water quality degradation, the use of a specific type of mechanical environmental dredge, the Cable Arm® (Model 100E) will be used for dredged removal to -3 ft ambient bottom. The Cable Arm® clamshell has demonstrated successes in the Great Lakes Cleanup demonstrations at Hamilton Harbor, Ontario Hydro and Toronto Harbor (SEDTEC, 1997), U.S. Navy at Pier D, Bremerton, Washington, and at the Dow Chemical facility in Freeport, Texas. This unit presents the best option for sediment cleanup with minimal water quality impacts.

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Conventional excavating equipment can be used for removing contaminated sediment and debris in shallow water. Although normally land-based, the excavator or backhoe can be positioned on a floating equipment spud-barge for dredging. Large construction excavators are available locally and can handle 2- to 3-cy buckets allowing dredging depths approaching 20 ft. Land-based dredging could dispose dredged material into waiting trucks equipped with sealed beds, while barge mounted excavators would require a haul barge similar to clamshell dredging.

Mechanical dredging is the only dredging technology appropriate for removal of the 50 percent wood waste, heavy wood debris, and for wooded Grey Zone sediments if dredging of these materials is required in the final remedy. Unit costs for mechanical removal of contaminated sediments are dependent upon the particular remedial alternative selected, but are generally between $40 and $60 per cy. Wood waste and Grey Zone removal will be between $8 and $12 per cy.

Hydraulic Dredging

Hydraulic dredges remove and transport dredged materials as a pumped sediment-water slurry. The sediment is dislodged by mechanical agitation (e.g., cutterhead, augers, or by high-pressure water jets). In very soft sediment, it may be possible to remove surface sediment by straight suction and/or by forcing the intake into the sediment without dislodgement. The loosened slurry is essentially then "vacuumed" into the intake pipe by the dredge pump and transported over long distances through the dredge discharge pipeline

Application of hydraulic dredging to the removal of contaminated sediment at the Port Quendall site is limited as follows:

- Hydraulic dredging is applicable only to the full, partial, and nearshore containment facility removal options. Presence of wood debris which will clog the hydraulic pipeline, would lead to dredging down time and water quality problems. The proposal to use hydraulic dredging assumes that large quantities of wood debris are not present in the dredging area.

- The area of the CDF is insufficient to handle bulked hydraulic sediment slurry.

- Wood waste (above 50 percent) cannot be dredged using hydraulic dredging.

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The cutterhead hydraulic pipeline dredge is selected for FS conceptual design. This is the most common hydraulic dredge, with about 10 capable portable dredges in the small to medium size range available in the Pacific Northwest. Available operator experience and skills are high. Sediment remedial investigations by others (U.S. Army Corps of Engineers, U.S. EPA, Environment Canada) have rated highly the small cutterhead dredge for contaminated sediment removal. The cutterhead is the only hydraulic dredge capable of effective operations if debris is present.

Unit costs for hydraulic sediment removal of contaminated sediments are dependent upon the particular remedial alternative selected, but are generally between $50 and $70 per cy.

4.3.2 Capping

Sediment capping technologies are appropriate to both the Sediment Cap and Enhanced Natural Recovery options. While placement technologies are similar, the difference is that the Sediment Cap would require placement of clean material to a depth of 3 ft to isolate contaminants, while Enhanced Natural Recovery would place only 6 inches of materials.

There is a variety of capping placement methods either used or considered elsewhere (Palermo *et al.*, 1995). The methods include hydraulic pipeline delivery to either a floating spreader box or submerged diffuser; dozing, clamming or washing of barged capping materials to settle through the water column; distribution by controlled discharge from hopper barges; mechanically-fed tremie to the bottom; high-pressure spraying (monitoring) of a hydraulic sediment-water slurry across the water surface. Important factors in selecting the cap placement method is to assure minimum capping thickness over the entire remedial area, limit resuspension and loss of contaminated sediment to the water column, and prevent mixing of the contaminated sediment into the emerging cap layer. Experience elsewhere has confirmed that allowing the capping materials to settle through the water column rather than impact the bottom as a dumped mass or density-driven hydraulic flow will tend to satisfy these requirements.

Based on considerations presented in the *Sediment Technologies Memorandum* (RETEC, 1997t), the clamshell placement method is selected for the FS development as the best method to more reliably achieve the required accurate and consistent placement of a cap at Port Quendall. Unit costs used for cap placement range between $8 and $14 per cy.

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4.4 Summary of Screened Remedial Technologies

A summary of technologies that will continue to be considered for inclusion in remedial alternatives is provided in Table 4-3. Technologies that were used for remedial alternative development, evaluation, and cost estimating are indicated on the table in bold type. As this FS deals specifically with considerations for the Port Quendall project, technologies not used in this FS are not precluded from use during site remediation conducted under different development assumptions.

5 Screening of Media-Specific Alternatives

This section provides a preliminary evaluation of remedial alternatives for the Port Quendall development. Based on the affected media and inter-relationships between the alternatives considered, the alternatives were divided into four categories:

- A - Soil (Includes soil treatment, DNAPL recovery, and capping)
- B - Sediment (Includes mitigation)
- C - Groundwater
- D - Containment Wall

Unlike a traditional FS, in which the universe of remedial technologies is put into the screening process, this FS only considers those alternatives which contribute to a minimum level of protectiveness and which are compatible with the proposed Port Quendall redevelopment project. Alternatives such as "no further action" that do not meet these project-specific criteria have not been excluded prior to the screening step.

5.1 Screening Criteria

This preliminary screening was performed to reduce the number of remedial alternatives for detailed evaluation. Preliminary screening was performed based on the following three criteria:

- Implementability
- Effectiveness
- Cost

Screening was based on a relative comparison between each collection of media-specific alternatives as described below.

5.1.1 Implementability

The technical ability to implement and operate a remedial alternative was evaluated. Most alternatives selected included the use of conventional technologies with readily available equipment; therefore, most alternatives evaluated in this section are implementable. Rather than provide a simple rating for each alternative, a brief discussion is provided in tabular form in the following

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sections. Other issues, such as schedule constraints of alternatives were also considered under implementability.

5.1.2 Effectiveness

The evaluation of effectiveness included short-term effectiveness, long-term effectiveness, protection of human health and the environment, and reduction in volume, mobility, or toxicity. Rather than provide a simple rating for each alternative, a brief discussion is provided in tabular form in the following sections. Short-term effectiveness considers problems such as exposure of remediation or construction workers to contaminants or physical dangers. Long-term effectiveness considers the degree of certainty that the alternative will be successful. Protection of human health and the environment considers risk reduction, and reduction in volume, mobility, or toxicity considers destruction of contaminants rather than containment.

5.1.3 Cost

Costs were evaluated on a relative scale for both capital and operations and maintenance. A continuous scale of minimal to very high was used to describe costs. Detailed costs will only be used for the detailed alternatives analysis presented in Section 6.

5.2 Soil Alternatives

Soil remedial alternatives are compiled and evaluated in Table 5-1. Soil remedial alternatives include soil treatment, DNAPL recovery, and capping since these three activities are inextricably linked. Six alternatives were selected based on the extent of soil treatment and included:

- Alternative A0 - No soil treatment
- Alternative A1 - Hazardous waste treatment (Baxter Lagoon)
- Alternative A2 - Nearshore DNAPL (Quendall Pond and Baxter Lagoon)
- Alternative A3 - All DNAPL
- Alternative A4 - All soil exceeding groundwater protection standards
- Alternative A5 - All soil exceeding Method B criteria

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Table 5-1 Screening of Soil Remedial Alternatives

Alternative Number	Soil: Treatment	Soil: DNAPL Recovery	Soil: Cap	Implementability	Effectiveness	Cost	Comments
A0	No soil treatment	North Sump Quendall Pond Former May Creek	All areas exceeding Method B criteria	Easy to implement Minimal trenching required	Limited short-term exposure for workers Limited contaminant volume reduction Potential long-term exposure concerns	Minimal capital cost Significant O&M cost	Retained as the minimum protective soil alternative May require cased piles or other development considerations
A1	Hazardous Waste	North Sump Quendall Pond Former May Creek	Remaining areas exceeding Method B criteria	Easy to implement Minimal trenching and excavation required	Limited short-term exposure for workers Limited contaminant volume reduction Potential long-term exposure concerns	Low capital cost Significant O&M cost	Removal of listed hazardous waste only May require cased piles or other development considerations
A2	Nearshore DNAPL	North Sump Former May Creek	Remaining areas exceeding Method B criteria	Requires excavation dewatering and treatment Likely requires temporary sheet pile installation along shoreline	Some short-term exposure for workers Some contaminant volume reduction Reduced long-term exposure concerns	Moderate capital cost High O&M cost	Removal of soil that represents a potential risk to lake sediments and water quality Some development considerations
A3	All DNAPL	North Sump	Remaining areas exceeding Method B criteria	Requires extensive excavation dewatering and treatment Likely requires temporary sheet pile installation along shoreline	Significant short-term exposure for workers Significant contaminant volume reduction Limited long-term exposure concerns	High capital cost Moderate O&M cost	Removal of all soil wirh DNAPL deposits
A4	All soil exceeding ground-water protection criteria	North Sump	Remaining areas exceeding Method B criteria	Requires extensive excavation dewatering and treatment Likely requires temporary sheet pile installation along shoreline Schedule and staging concerns due to large excavation volumes	Significant short-term exposure for workers Significant contaminant volume reduction Limited long-term exposure concerns	Very high capital cost Moderate O&M cost	Capital cost and schedule constraints are too extensive
A5	All soil exceeding Method B criteria	North Sump	None	Requires extensive excavation dewatering and treatment Likely requires temporary sheet pile installation along shoreline Schedule and staging concerns due to large excavation volumes	Significant short-term exposure for workers Significant contaminant volume reduction Limited long-term exposure concerns	Very high capital cost Low O&M cost	Capital cost and schedule constraints are too extensive

(shaded) Alternative Screened Out

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As stated previously, all of these alternatives could be protective within the context of a site-wide remedy. The extent of soil treatment and protectiveness obviously increases throughout the alternatives. Implementability decreases as larger portions of the site are treated and extensive dewatering is required for conventional excavation techniques. Cost increases substantially and schedule constraints become a concern as the soil treatment areas increase. Given the complete analysis, Alternatives A4 and A5 were eliminated due to the high costs and schedule constraints. Alternative A0, although not considered a preferred alternative, was retained as a base case for the detailed evaluation.

5.3 Sediment Alternatives

Sediment alternatives were preliminarily evaluated as summarized in Table 5-2. Five sediment alternatives were evaluated as follows:

- Alternative B0 - Capping
- Alternative B1 - CDF (2.9 acres)
- Alternative B2 - Nearshore Containment (0.5 acres)
- Alternative B3 - Nearshore Dredging
- Alternative B4 - Nearshore Dredging (Deep Chase)

Alternatives B1, B2, and B3 are all moderately easy to implement. The capping alternative is the easiest to implement while the deep nearshore chase is much more difficult to implement. The nearshore chase would require installation of temporary steel piles in the lake, dewatering, and conventional excavation of the nearshore in conjunction with excavation of the Quendall Pond upland area.

Alternatives B1, B2, and B3 are all moderately effective as defined by MTCA criteria. However, the effectiveness does increase slightly from B1 to B2 to B3 due to the increased destruction of contaminants rather than containment. The capping alternative is equally protective but has a lower effectiveness rating under MTCA criteria. The deep chase alternative is slightly more effective as additional contaminants will be removed and destroyed but is extremely difficult to implement.

Alternatives B1, B2, and B3 also all have similar costs; however, the costs increase slightly with increased dredging and upland treatment. The capping alternative is the least cost alternative while the nearshore deep chase is the most expensive. The capping alternative was eliminated based on options expressed by Ecology and other resource agencies during the Port Quendall project meetings. The nearshore deep chase alternative was eliminated due to high capital costs, schedule concerns, and the difficulty of implementation.

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Table 5-2 Screening of Sediment Remedial Alternatives

Alternative Number	Sediment		Implementability	Effectiveness	Cost	Comments
	Treatment	Mitigation				
B0	Cap - T-Dock Wood Waste Nearshore Excavate Baxter Cove	Wetland Replacement Gypsy Creek Realign 0.5 acre fill mitigation	Easy to implement May be dropped from barge or placed by mechanical dredge equipment	Limited short-term exposure for workers Short-term turbidity in surface water Limited contaminant volume reduction Potential long-term exposure concerns	Minimal capital cost High long-term O&M costs	Capping alternative dropped based on opinions expressed by Ecology and resource agencies during Port Quendall project meetings
B1	Remove/Recycle Wood Waste CDF - 2.9 acres Dredge and CDF T-Dock Nearshore Toe Excavate Baxter Cove Grey Zone Natural Recovery	Wetland Replacement Gypsy Creek Realign 2.9 acre CDF mitigation	Requires construction of in-water berm with containment wall along outer shore May perform in situ biological treatment in CDF	Some short-term exposure for workers Short-term surface water quality concerns Limited contaminant volume reduction Reduced long-term exposure concerns	Moderate capital cost Moderate long-term O&M costs	CDF outer wall would contain all NAPL seeps in nearshore
B2	Remove/Recycle Wood Waste Contain Nearshore Benzene and NAPL Dredge and Upland Mgmt T-Dock Nearshore Partial Excavate Baxter Cove Grey Zone Enhanced Natural Recovery	Wetland Replacement Gypsy Creek Realign 0.5 acre fill mitigation	Easy to implement Assumes containment wall along outer shore of cap	Some short-term exposure for workers Short-term surface water quality concerns Some contaminant volume reduction Reduced long-term exposure concerns	Moderate capital cost Moderate long-term O&M costs	Containment wall in water would contain nearshore shallow DNAPL Some NAPL remains outside wall at depth
B3	Remove/Recycle Wood Waste Dredge and Upland Mgmt Grey Zone T-Dock Nearshore to max. 5 feet below mud line Excavate Baxter Cove	Wetland Replacement Gypsy Creek Realign	More difficult to implement May require temporary piling in lake Schedule concerns due to large volume and difficult excavation	Some short-term exposure for workers Short-term surface water quality concerns Some contaminant volume reduction Reduced long-term exposure concerns	High capital cost Low long-term O&M costs	Upland containment wall would leave some NAPL uncontained
B4	Remove/Recycle Wood Waste Dredge and Upland Mgmt Grey Zone T-Dock Nearshore - chase seep during Quendall Pond excavation Excavate Baxter Cove	Wetland Replacement Gypsy Creek Realign	Difficult to implement Requires temporary piling in lake Excavation dewatering required Schedule concerns due to large volume and difficult excavation	Significant short-term exposure for workers Short-term surface water quality concerns Large contaminant volume reduction Limited long-term exposure concerns	Very high capital cost No O&M costs	Capital cost extremely high Schedule not compatible with development needs Major Implementability concerns

(shaded) Alternative Sceened Out

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5.4 Groundwater Alternatives

Groundwater remedial alternatives considered were: natural attenuation, biosparging, and biosparging with pump-and-treat (hydraulic containment). All of these alternatives are essentially used for containment, to prevent discharge of impacted groundwater to Lake Washington surface waters. Both the biosparging and pump-and-treat system would be installed in conjunction with a physical containment wall.

All three alternatives use conventional technologies and, as such, are easily implemented. All the alternatives represent little contaminant reduction, and long-term effectiveness is much greater in the third alternative because the pump-and-treat system would act as a backup to the biosparging system. The cost for the biosparging is moderate, while the additional cost for the pump-and-treat system is much larger due to both capital and operating expenditures. A summary of this analysis is provided in Table 5-3.

Natural attenuation may be an effective means for containment of groundwater contaminants in specific areas of the site. The treatability testing demonstrated that with adequate oxygen, high rates of biological degradation of groundwater contaminants including benzene could be achieved. The modeling work conducted by RETEC indicated that if some contaminant degradation of the contaminants can be achieved and if the distance between the source area and the point of exposure are adequate, natural attenuation can be extremely effective at preventing exceedences of cleanup standards at the point of exposure.

However, in evaluating natural attenuation performance for use during the Port Quendall project, RETEC elected to use conservative assumptions regarding the performance of natural attenuation. Conservative assumptions were used to provide Port Quendall with a high degree of certainty for any remedies proposed for use. Based on the assumptions used and the output from groundwater modeling, natural attenuation was assumed to be ineffective for treatment of contamination from shoreline source areas, except where those source areas were removed (i.e., through aggressive excavations of DNAPL-impacted soils). Because the removal of all shoreline and nearshore DNAPL was determined to be impracticable during the remedy screening process, natural attenuation (Alternative C0) was not included in the detailed evaluation of remedies.

5.5 Containment Wall Alternatives

The containment wall alternatives are discussed separately, although the choice of containment wall alternative is highly dependent on the choice of sediment

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Table 5-3 Screening of Groundwater Remedial Alternatives

Alternative Number	Groundwater	Implementability	Effectiveness	Cost	Comments
C0	Natural Attenuation	Easy to implement May require some well installation	Minimal short-term exposure for workers Limited contaminant volume reduction Potential long-term exposure concerns	Minimal capital cost Moderate O&M cost	Effectiveness assumed to be limited in some areas by short contaminant travel times
C1	Biosparge	Easy to implement	Minimal short-term exposure for workers Some contaminant volume reduction Reduced potential long-term exposure concerns	Moderate capital cost Moderate O&M cost	Biosparge system along shoreline to treat groundwater prior to discharge to lake
C2	Biosparge and pump-and-treat	Easy to implement Lots of maintenance likely due to high iron and carbonate concentrations	Minimal short-term exposure for workers Some contaminant volume reduction Reduced potential long-term exposure concerns	High capital cost High O&M cost	Pump-and-treat system used as back-up in event of water quality exceedances

Alternative Screened Out

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remedial alternative, with the exception of choosing to forego a containment wall. The containment wall alternatives vary only based on alignment. Due to the nature of the lakeshore environment, the depth of the containment wall will only be to 30 ft, or completely penetrating the upper silty peat layer. The inability of deeper walls to substantially impact groundwater fate and transport is discussed in the *Port Quendall Groundwater Model and Hydrogeologic Analysis of Alternatives* (RETEC, 1997u).

All containment wall alternatives are easily implemented and the effectiveness and costs are similar as the only variable is length. The alternative for no containment wall was eliminated from consideration due to concerns about enhanced DNAPL mobilization during the proposed Port Quendall development project (due to soil loadings) and the high cost of conducting aggressive soil excavations that would be required to integrate these concerns by Port Quendall without the use of a containment wall. A summary of the containment wall evaluation is provided in Table 5-4.

5.6 Summary of Remaining Media-Specific Alternatives

Table 5-5 presents a summary of media-specific remedial alternatives that remain for compilation into site-wide remedial alternatives and detailed evaluation. These alternatives include four soil, three sediment, two groundwater, and three containment wall alternatives.

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Table 5-4 Screening of Containment Wall Remedial Alternatives

Alternative Number	Containment Wall	Implementability	Effectiveness	Cost	Comments
D0	None	Easy to implement	No short-term exposure for workers No contaminant volume reduction Long-term NAPL migration concerns	No cost	Containment wall assumed to be necessary for Port Quendall high-densit development unless NAPL is removed
D1	Upland Wall	Easy to implement May use slurry wall or sheet piling techniques	Limited short-term exposure for workers No contaminant volume reduction Moderate long-term NAPL migration concerns	Moderate capital cost	Nearshore NAPL would remain outside wall
D2	Nearshore Wall (0.5 acre cap)	Easy to implement Slurry techniques may may not be viable in unconsolidated fill	Limited short-term exposure for workers No contaminant volume reduction Low long-term NAPL migration concerns	Moderate capital cost, may be high if slurry techniques are not viable	Shallow nearshore NAPL would be contained
D3	Nearshore Wall (2.9 acre CDF)	Easy to implement Slurry techniques may may not be viable in unconsolidated fill	Limited short-term exposure for workers No contaminant volume reduction Minimal long-term NAPL migration concerns	Moderate capital cost, may be high if slurry techniques are not viable	All nearshore NAPL at Quendall Pond would be contained

(shaded) Alternative Screened Out

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Table 5-5 Screening Summary for Media-Specific Remedial Alternatives

Alternative Number	A - Soil: Treatment	A - Soil: DNAPL Recovery	A - Soil: Cap	B - Sediment: Treatment	B - Sediment: Mitigation	C - Groundwater	D - Containment Wall
0	No soil treatment	North Sump Quendall Pond Former May Creek	All areas exceeding Method B criteria	Cap - T-Dock Wood Waste Nearshore Excavate Baxter Cove	Wetland Replacement Gypsy Creek Realign 0.5 acre fill mitigation	Natural Attenuation	None
1	Hazardous Waste	North Sump Quendall Pond Former May Creek	Remaining areas exceeding Method B criteria	Remove/Recycle Wood Waste CDF - 2.9 acres Dredge and CDF T-Dock Nearshore Toe Excavate Baxter Cove Grey Zone Natural Recovery	Wetland Replacement Gypsy Creek Realign 2.9 acre CDF mitigation	Biosparge	Upland Wall
2	Nearshore DNAPL	North Sump Former May Creek	Remaining areas exceeding Method B criteria	Remove/Recycle Wood Waste Cap Nearshore Benzene Dredge and Upland Mgmt T-Dock Nearshore Partial Excavate Baxter Cove Grey Zone Enhanced Natural Recovery	Wetland Replacement Gypsy Creek Realign 0.5 acre fill mitigation	Biosparge and pump-and-treat	Nearshore Wall (0.5 acre cap)
3	All DNAPL	North Sump	Remaining areas exceeding Method B criteria	Remove/Recycle Wood Waste Dredge and Upland Mgmt Grey Zone T-Dock Nearshore to max. 5 feet below mud line Excavate Baxter Cove	Wetland Replacement Gypsy Creek Realign		Nearshore Wall (2.9 acre CDF)
4	All soil exceeding surface water protection criteria	North Sump	Remaining areas exceeding Method B criteria	Remove/Recycle Wood Waste Dredge and Upland Mgmt Grey Zone T-Dock Nearshore - chase seep during Quendall Pond excavation Excavate Baxter Cove	Wetland Replacement Gypsy Creek Realign		
5	All soil exceeding Method B criteria	North Sump	None				

Alternative Screened Out or Cell Not Used

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6 Detailed Compilation and Analysis of Alternatives

6.1 Compilation of Alternatives

This section includes the detailed evaluation of remedial alternatives carried forward from Section 5. Following screening of media-specific remedial alternatives in that Section, four soil and groundwater alternatives and three sediment and containment wall alternatives have been selected for detailed evaluation in this study. The alternatives carried forward are listed in Table 6-1. These media-specific alternatives where then combined into site-wide remedy combinations that comprehensively address soil, groundwater and sediment issues. A total of twelve remedy combinations is evaluated in this section. These include the following:

Alternative #1: AC0 + BD1	No Soil Treatment and containment of sediments in a 2.9 acre confined disposal facility (CDF)
Alternative #2: AC0 + BD2	No Soil Treatment and Nearshore Containment in a 0.5 acre confined disposal facility
Alternative #3: AC0 + BD3	No Soil Treatment and Upland Treatment/disposal of sediments
Alternative #4: AC1 + BD1	Hazardous Waste Treatment and CDF
Alternative #5: AC1 + BD2	Hazardous Waste Treatment and Nearshore Containment
Alternative #6: AC1 + BD3	Hazardous Waste Treatment and Upland Treatment/Disposal of Sediments
Alternative #7: AC2 + BD1	Nearshore DNAPL Treatment and CDF
Alternative #8: AC2 + BD2	Nearshore DNAPL Treatment and Nearshore Containment

Table 6-1 Summary of Media-Specific Remedial Alternatives

Alternative Number	AC - Soil and Groundwater				Alternative Number	BD - Sediment and Containment Wall		
	Treatment	DNAPL Recovery	Cap	Groundwater		Treatment	Mitigation	Containment Wall
AC0	No soil treatment	North Sump Quendall Pond Former May Creek	All areas exceeding Method B criteria	Biosparge with pump-and-treat as contingency	BD0			
AC1	Hazardous Waste	North Sump Quendall Pond Former May Creek	Remaining areas exceeding Method B criteria	Biosparge with pump-and-treat as contingency	BD1	Remove/Recycle Wood Waste CDF - 2.9 acres Dredge and CDF T-Dock Nearshore Toe Excavate Baxter Cove Grey Zone Natural Recovery	Wetland Replacement Gypsy Creek Realign 2.9 acre CDF mitigation	Nearshore Wall (2.9 acre CDF)
AC2	Nearshore DNAPL	North Sump Former May Creek	Remaining areas exceeding Method B criteria	Biosparge with pump-and-treat as contingency	BD2	Remove/Recycle Wood Waste Cap Nearshore Quendall Dredge and Upland Mgmt T-Dock Nearshore Partial Excavate Baxter Cove Grey Zone Enhanced Natural Recovery	Wetland Replacement Gypsy Creek Realign 0.5 acre fill mitigation	Nearshore Wall (0.5 acre cap)
AC3	All DNAPL	North Sump	Remaining areas exceeding Method B criteria	Biosparge - no contingency required	BD3	Remove/Recycle Wood Waste Dredge and Upland Mgmt Grey Zone T-Dock Nearshore to max. 5 feet below mud line Excavate Baxter Cove	Wetland Replacement Gypsy Creek Realign	Upland Wall

Alternative #9: AC2 + BD3	Nearshore DNAPL Treatment and Upland Treatment/Disposal of Sediments
Alternative #10: AC3 + BD1	All DNAPL Treatment and CDF
Alternative #11: AC3 + BD2	All DNAPL Treatment and Nearshore Containment
Alternative #12: AC3 + BD3	All DNAPL Treatment and Upland Treatment/Disposal of Sediments

All of the remedies discussed in this section meet a minimum threshold of protectiveness. This threshold has been defined as compliance with cleanup levels and ARARs at the point of compliance and protection of human health and the environment under the development's proposed land use assumptions. The remedies and remedy combinations differ from each other in how this protection is achieved. Some remedies and remedy combinations use primarily containment strategies to address soil and sediment contamination, whereas other remedies use primarily removal and treatment strategies. The extent of removal and treatment used within each remedy impacts its capital costs, anticipated and contingent long-term costs, short-term effectiveness, long-term effectiveness, and implementability. These issues are discussed within this section.

In addition, the extent of removal and treatment also impacts the development planning and liability considerations of Port Quendall. For the purposes of this feasibility analysis, it has been assumed that if areas of free DNAPL remain in soils after completion of the cleanup, this will require concessions in development planning. These concessions would include either selective building placement (keeping buildings with pile foundations out of DNAPL areas) or would require special piling designs (use of double-cased pilings).

Note that in the discussion of sediment remedies, RETEC has assumed that a removal action would be taken with respect to wood waste (areas defined as >50 percent wood waste) under all three of the alternatives carried forward and that capping of sediments in the DNR lease lands would not be performed. These assumptions were based on the status of discussions with the Department of Ecology and other resource agencies at the time that this document was prepared. Other assumptions regarding these issues could be equally valid but were not included in the detailed remedy evaluation based on agency opinions expressed during the Port Quendall project meetings. The dredging of the grey zone has

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been included in the alternatives analysis pending the outcome of further testing of this material.

6.2 Evaluation Criteria

Analysis of the four soil and groundwater alternatives and the three sediment and containment wall alternatives selected for detailed screening will be based on the following criteria, as specified in WAC 173-340-360(5)(d).

6.2.1 Protection of Human Health and the Environment

As described above, all remedies included in the detailed evaluation step meet the minimum level of protectiveness defined by compliance with cleanup levels and ARARs and by protection of human health and the environment under proposed land use assumptions.

6.2.2 Long-term Effectiveness and Permanence

The long-term effectiveness and permanence criterion is primarily concerned with residual risk remaining at the site after completion of the remedial action. This analysis includes consideration of the degree of threat posed by the hazardous substances remaining at the site (after completion of the remedial action) and the adequacy of any controls used to manage these hazardous substances. Alternatives that afford the highest degree of long-term effectiveness and permanence are those that minimize waste remaining at the site such that long-term maintenance is unnecessary and reliance on institutional controls is minimized.

This criterion is based on the preference stated in WAC 173-340-360 to utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. As part of the measure of long-term effectiveness, the 95 percent upper confidence limit (UCL) was calculated for TPAH in soil remaining after the site-wide remedy has been implemented.

Long-term effectiveness will be evaluated qualitatively relative to the other alternatives. Those alternatives that do not protect from future releases will rate poorly for long-term effectiveness.

6.2.3 Short-term Effectiveness

The short-term effectiveness criterion addresses the effects to human health and the environment of the alternative during the construction and implementation phase until remedial response objectives are met. Factors used in assessing short-term effectiveness are:

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- Short-term risks posed to the community during implementation of the alternative
- Risks to site workers during implementation
- Environmental impacts that may be caused by implementation
- The length of time that the short-term risks may be required

Where risks associated with an alternative are identified, an evaluation is included on how risks may be mitigated and what risks, if any, cannot be readily controlled.

Short-term effectiveness will be evaluated qualitatively relative to the other alternatives. Those alternatives that permit exposure will rate poorly for short-term effectiveness.

6.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The reduction of toxicity, mobility, or volume through treatment criteria is a reflection of Ecology's expectation under WAC 173-340-360(9)(j) to implement remedial actions that employ treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of the hazardous substances as a principal element. This criterion is used to assess:

- The volume of impacted media treated or recycled
- The degree to which the treatment is irreversible
- The type and quantity of the treatment residues
- The degree to which treatment reduces principal site concerns

This criterion was evaluated based upon the quantity of TPAH that was treated during soil and sediment remedial alternatives. Volume reduction from DNAPL recovery and groundwater remediation are assumed to be negligible, although the presence of these systems will certainly improve long-term effectiveness.

6.2.5 Implementability

The implementability criterion includes an evaluation of the technical and administrative feasibility of implementing the alternative and the availability of various services and materials required for implementation. Technical feasibility includes the ease with which alternatives may be constructed, operated, and monitored. Administrative feasibility is based upon such things as coordinating with other agencies, obtaining permits or meeting requirements for on-site and off-site activities, and identifying the availability of the prospective technologies.

Implementability will be evaluated qualitatively relative to other remedial alternatives. The use of innovative technologies or requirements for temporary shoring, dewatering, or in-water construction will have reduced levels of implementability. The use of conventional technologies in a conventional manner will increase the implementability.

6.2.6 Cost and Cost Effectiveness

Cost estimates were prepared for implementation of each alternative. These estimates include capital costs plus the present worth of future operating and maintenance costs amortized over the expected life of the project. The individual cost estimates and a list of the assumed unit costs and other engineering assumptions are provided in Appendix A. A summary of the cost estimates for soil and groundwater (AC) alternatives is provided in Table 6-2 and for sediment and containment wall (BD) alternatives is provided in Table 6-3.

Cost estimates developed for the FS were based on interpretation of existing data to provide the most probable estimate. Section 7 provides "Probable Least" and "Probable Upper" costs. The "Probable Least" costs are consistent with costs provided throughout the FS. The "Probable Upper" costs were developed by including factors for certain aspects of the cleanup. For example, all excavation and dredge volumes were developed for the "Probable Upper" costs using an uncertainty factor of 1.7. Other uncertainty factors are provided in the detailed cost estimates in Appendix A.

Cost estimates were developed for independent remedial activities within the alternatives to allow easy evaluation of minor modifications to the alternatives analyzed. These costs are based on a variety of information available at the time of the estimate, including generic unit costs, vendor information, conventional cost estimating guides, and prior experience. The actual cost of the alternative will depend on true labor and material costs, site conditions, competitive market conditions, final project scope, the implementation schedule, and other variable factors. This criterion will provide information for the comparison of cost effectiveness among alternatives.

Capital costs were estimated for each alternative that involves the design and construction of facilities or the one-time costs of short-term remediation efforts. Examples of items included in the capital costs include:

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Table 6-2 Soil and Groundwater (AC) Remedial Alternatives Cost Estimates

	AC0 - No Soil Treatment	AC1 - Hazardous Waste	AC2 - Nearshore DNAPL	AC3 - All DNAPL
Soil Treatment	$0	$702,945	$3,072,071	$9,894,458
Mobilization/Site Prep			506,674	506,674
Hazardous Waste		702,945	702,945	702,945
Quendall Pond			1,862,452	1,862,452
Former May Creek				1,306,380
Baxter Nearshore				1,513,787
North Sump				908,208
Still House				2,302,929
Baxter Farshore				483,108
Baxter Farshore				307,975
DNAPL Recovery	$1,868,320	$1,868,320	$1,405,136	$941,952
Mobilization/Site Preparation	63,500	63,500	63,500	63,500
North Sump	878,452	878,452	878,452	878,452
Quendall Pond	463,184	463,184		
Former May Creek	463,184	463,184	463,184	
Cap	$2,931,601	$2,931,601	$2,811,398	$1,968,875
Mobilization/Site Preparation	63,500	63,500	63,500	63,500
Quendall Pond	120,203	120,203		
Former May Creek	134,097	134,097	134,097	
Baxter Nearshore	123,017	123,017	123,017	
North Sump	113,876	113,876	113,876	
Still House	371,074	371,074	371,074	
Baxter Farshore	100,459	100,459	100,459	
Other Method B Exceedances	1,905,375	1,905,375	1,905,375	1,905,375
Groundwater	$5,305,130	$5,305,130	$5,305,130	$1,973,726
Biosparging	999,167	999,167	999,167	999,167
Groundwater Extraction	3,331,404	3,331,404	3,331,404	
Institutional Controls/Monitoring	974,559	974,559	974,559	974,559
TOTAL COST	$10,100,000	$10,800,000	$12,600,000	$14,800,000

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Table 6-3 Sediment and Containment Wall (BD) Remedial Alternatives Cost Estimates

	BD1 - CDF (2.9 acres)	BD2 - Containment (0.5 acres)	BD3 - Nearshore Removal
Sediment Remediation	$5,630,206	$7,551,655	$11,005,972
Mobilization/Site Preparation	486,600	486,600	486,600
Remove/Recycle Wood Waste	2,201,595	2,201,595	2,201,595
Grey Zone Dredging			3,603,727
Grey Zone Natural Recovery	254,983		
Grey Zone Enhanced Recovery		462,530	
CDF, Dredge T-Dock & Nrshr	2,544,972		
Containment, Dredge Nearshore		2,441,045	
T-Dock Dredging		1,817,829	1,817,829
Nearshore Dredging (6' max)			2,754,165
Baxter Cove	142,056	142,056	142,056
Mitigation	$1,524,000	$1,524,000	$1,016,000
Wetland Replacement	508,000	508,000	508,000
Gypsy Creek Realignment	508,000	508,000	508,000
For CDF (2.9 acres)	508,000		
For Containment (0.5 acres)		508,000	
Containment Wall	$1,327,500	$1,256,250	$1,173,333
Upland Wall			1,173,333
Nearshore Wall		1,256,250	
CDF Outer Wall	1,327,500		
TOTAL COST	$8,500,000	$10,300,000	$13,200,000

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- Groundwater treatment facilities
- Dredging of impacted sediment
- Installation of a cap
- Treatment of soil
- Engineering and construction management associated with the above tasks

Operations and maintenance costs are all costs associated with the operation of a remediation system that must operate continuously or repetitively for a period of years to accomplish its objectives. Examples of operations and maintenance costs are those costs associated with:

- Long-term operation of a biosparging system, including labor and utilities
- Inspection and repairs to an asphalt pavement cap
- Periodic groundwater sampling and reporting

For purposes of economic analysis in the study, it was assumed that operation of a contingent groundwater extraction and treatment system and natural recovery monitoring for sediment would occur for 10 years. All other long-term maintenance and monitoring costs were assumed to have a duration of 30 years.

In comparing the cost of multiple alternatives, it is necessary to utilize calculation methods that recognize that a future operating and maintenance cost is not as expensive as a current capital cost, even though the amount of expenditure may be the same. The recognized method for comparing these two types of costs is by using the present worth cost of future expenditures. Present worth is defined as the amount of money that could be invested now and that would provide sufficient funds, including returns from investment, to pay for a defined future series of annual expenditures. These calculations were performed using the @PV built-in function for the spreadsheet software package. The following formula is used for the calculation:

$$P = \frac{R[(1 + i)^n - 1]}{i(1 + i)^n}$$

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where P = Present worth of a uniform series of annual expenditures
R = Annual expenditure
I = Return on investment
N = Number of annual expenditures in the series

Cost effectiveness is a measure of practicability. A cleanup alternative is not considered "practicable" if the incremental cost of the alternative is "substantial and disproportionate to the incremental degree of protection this alternative would provide" (WAC 173-340-360(5)(d)(vi)).

6.2.7 Community Acceptance

Community acceptance refers to the type of input the public typically may present during the RI/FS process. The opinion of the community will be formally solicited during the public comment period. Assessment of the community acceptance criterion for the alternative will be completed following input from the community on the proposed CAP.

6.3 Evaluation of Soil and Groundwater Remedial Alternatives

The following sections describe the soil and groundwater remedial alternatives and provide a discussion of how the alternatives compared to the evaluation criteria. Table 6-4 provides a summary of these evaluations for each alternative.

6.3.1 Alternative AC0 - No Soil Treatment

Alternative AC0 includes no soil treatment and DNAPL recovery at the Former May Creek Channel, Quendall Pond, and the North Sump. Capping will be performed over most of the Quendall and Baxter properties. The cap will consist of 3 ft of soil on North Baxter and either development features or an otherwise impermeable cap (asphalt or HDPE liner) over all other areas.

Groundwater containment will be accomplished using a combination of *in-situ* biosparging and pump-and-treat technologies. Biosparging wells will be used to aerate the upper 20 ft of the sand and gravel aquifer. Groundwater extraction will also occur in this area if biosparging does not provide adequate containment. It is assumed that the groundwater treatment system will consist of an equalization tank, oil/water separation, sand filter, and granular activated carbon. A sequestering/complexing agent will be used to control inorganic precipitation and a biocide may be introduced to prevent biofouling. Water discharge is estimated to be at a rate of 100 gpm and will be discharged to Metro.

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Table 6-4 Detailed Evaluation of Soil and Groundwater Remedial Alternatives

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Alternative	Long-Term Effectivness	Short-Term Effectivness	Reduction in Mobility,Toxicity and Volume	Ability to Implement	Cost
AC0 No Soil Treatment	Potential long-term exposure concerns LOW	Limited short-term exposure for workers HIGH	Minimal contaminant volume reduction (0 tons PAH) TPAH 95% UCL 9,862 mg/kg LOW	Easy to implement HIGH	$10.4 M
AC1 Hazardous Waste Treatment	Potential long-term exposure concerns LOW	Limited short-term exposure for workers HIGH	Minimal contaminant volume reduction (9 tons PAH) TPAH 95% UCL 5,169 mg/kg LOW	Easy to implement HIGH	$11.1 M
AC2 Nearshore DNAPL Treatment	Reduced long-term exposure concerns near receptor MODERATE	Some short-term exposure for workers MODERATE	Limited contaminant volume reduction (174 tons PAH) TPAH 95% UCL 3,601 mg/kg MODERATE	Requires temporary piling and dewatering for excavation MODERATE	$12.8 M Excavation & Thermal $12.6 M In-Situ Stabilization
3 All DNAPL Treatment	Limited long-term exposure concerns HIGH	Significant short-term exposure for workers LOW	Significant contaminant volume reduction (543 tons PAH) TPAH 95% UCL 886 mk/kg HIGH	Requires temporary piling and dewatering for excavation LOW	$14.3 M Excavation & Thermal $15.6 M In-Situ Stabilization

Notes: All remedies meet the minimum threshold of effectiveness provided that they are applied in conjunction with suitable groundwater and containment wall remedies.

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This alternative receives a low rating for long-term effectiveness because the only reduction in contaminants will occur via groundwater treatment. Short-term effectiveness is high because only limited exposures will occur and the alternative is highly implementable.

6.3.2 Alternative AC1 - Hazardous Waste Treatment

Alternative AC1 includes excavation and off-site incineration of K001 soil from Baxter Lagoon. DNAPL recovery trenches will be installed at the Former May Creek Channel, Quendall Pond, and the North Sump. Capping will be performed as described for Alternative AC0, over most of the Quendall and Baxter properties.

A combination of biosparging and pump-and-treat technologies will be used as described for Alternative AC0.

The alternative is ranked identical to AC0, except that this alternative requires \$0.7 million extra for excavation and off-site incineration of Baxter Lagoon. Approximately 9 tons of PAH constituents will be permanently removed from the site and the TPAH 95 percent UCL will drop from 9,862 to 5,169 mg/kg, a 48 percent reduction.

6.3.3 Alternative AC2 - Nearshore DNAPL Treatment

This alternative includes treatment of Quendall Pond, in addition to Baxter Lagoon. Quendall Pond represents the greatest risk to the lake due to its proximity and the presence of higher mobility compounds. Capping will be performed for most of the Baxter and Quendall site, with the exception of the Quendall Pond area where Method B criteria should be satisfied.

A combination of biosparging and pump-and-treat technologies will be used, as described for Alternative AC0.

This alternative has slightly improved long-term effectiveness relative to the previous alternatives. The short-term effectiveness and implementability have decreased slightly due to the need for temporary sheet piling and dewatering for excavation. The reduction in contaminant volume remains low (147 tons), although the treatment of Quendall Pond removes the material that represents the greatest risk due to proximity, mobility, and toxicity. The TPAH 95 percent UCL will decrease to 3,601 mg/kg, a 63 percent reduction from initial conditions. The additional cost for treatment of Quendall Pond is approximately \$1.9 million.

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6.3.4 Alternative AC3 - All DNAPL Treatment

Additional soil treatment areas in this alternative include: Former May Creek channel, Still House, North Sump, Baxter Nearshore, and Baxter Farshore. A DNAPL recovery trench is included at the North Sump and capping will be performed for all areas where soil is not treated.

Due to the more extensive soil treatment, only *in-situ* biosparging will be implemented for groundwater treatment. This system will be installed along the downgradient side of the site for containment, as described for Alternative AC0.

This alternative ranks highest for long-term effectiveness and reduction in mobility, toxicity, and volume. This is due entirely to the more extensive soil treatment that removes a total of 543 tons of PAH constituents. Short-term effectiveness and implementability are the lowest for the alternatives due to the extensive dewatering and treatment required for excavation. The TPAH 95 percent UCL decreases to 886 mg/kg, a 91 percent reduction from initial conditions.

6.3.5 Contaminant Removal Summary

The extent of contaminant removal achieved using the soil and groundwater alternatives may be compared using the 95 percent UCL for COCs and TPAH following implementation and by comparing the total mass of PAH constituents removed or the mass of PAH constituents removed per 1,000 tons of soil treated. Table 6-5 summarizes this data, and the 95 percent TPAH UCL are compared on Figure 6-1.

6.4 Evaluation of Sediment and Containment Wall Alternatives

The following sections describe the sediment and containment wall remedial alternatives and provide a discussion of how the alternatives compared relative to evaluation criteria. Table 6-6 provides a summary of these evaluations for each alternative. Each of these alternatives includes dredging and upland management of the wood waste (above 50 percent) area and excavation and treatment or disposal of Baxter Cove sediments. Mitigation for all of the alternatives includes Gypsy Creek realignment and replacement of wetlands damaged during site remediation.

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Figure 6-1 TPAH Impacted Soil Volumes and Related UCLs

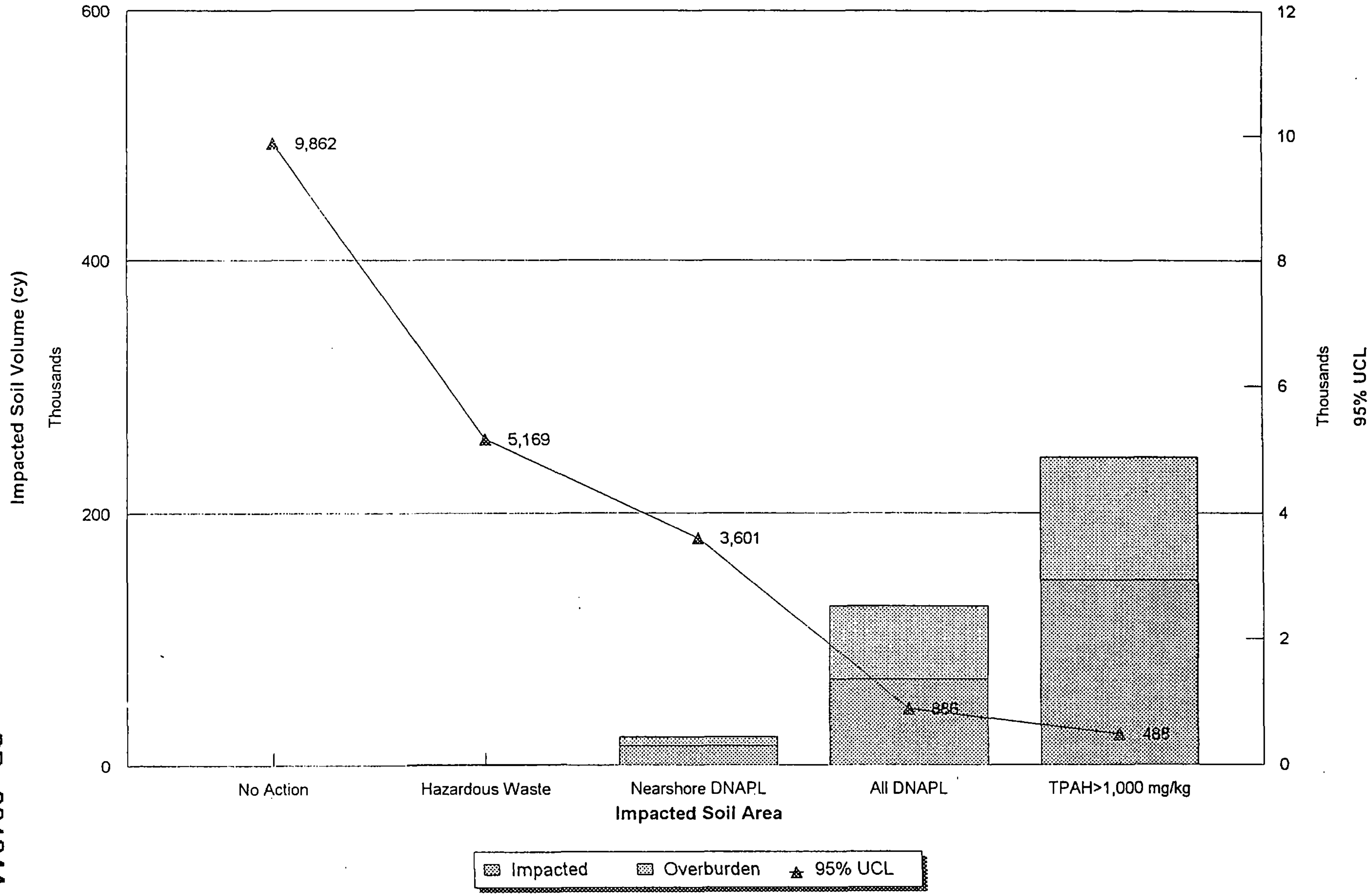

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Table 6-5 Soil Volume and Statistical Data Summary

Treated Soil Area	Benzene 95% UCL (µg/kg)	Naphthalene 95% UCL (mg/kg)	Chrysene 95% UCL (mg/kg)	TPAH 95% UCL (mg/kg)	Pounds PAH Per 1,000 Tons		Treated PAH Mass (tons)
					Total Soil	Impacted Soil	
No Treatment	322	2,337	116	9,862			0
Hazardous Waste	322	267	22	5,169	35.0	35.0	9
Nearshore DNAPL	322	180	15	3,601	12.4	18.0	147
All DNAPL	284	133	9	886	6.2	11.6	542
TPAH >1,000 mg/kg	150	26	5	488	2.6	4.3	856

6.4.1 Alternative BD1 - CDF

This alternative includes the construction of an approximately 2.9-acre CDF. The containment wall will be installed near the outer extent of the CDF to contain nearshore sediments and DNAPL seeps. PAH-impacted sediment from the T-Dock and the Quendall nearshore areas beyond the CDF will be dredged and placed in the CDF. The Grey Zone will be monitored for natural recovery and appropriate mitigation will be implemented for the CDF.

This alternative ranks high for long-term effectiveness since all impacted sediments are dredged and contained and all subsurface DNAPL seeps in the Quendall nearshore will be contained. However, this alternative also ranks low for volume reduction since dredged sediment is placed in the CDF and no destruction/detoxification occurs, except for that achieved through groundwater treatment. This alternative received moderate ratings for short-term effectiveness and implementability.

6.4.2 Alternative BD2 - Nearshore Containment

The nearshore containment alternative includes placement of an approximately 0.5-acre containment cell at the Quendall nearshore. This cell and containment wall along the outer extent will contain the most highly impacted sediments and most of the nearshore DNAPL seeps; some subsurface DNAPL seeps will remain beyond the containment wall. The T-Dock area and the Quendall nearshore area beyond the containment cell will be dredged and treated or disposed upland. Enhanced natural recovery and monitoring of the Grey Zone will be implemented. Appropriate mitigation for the 0.5-acre containment cell will be performed.

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Table 6-6 Detailed Evaluation of Sediment and Containment Wall Remedial Alternatives

Alternative	Long-Term Effectivness	Short-Term Effectivness	Reduction in Mobility,Toxicity and Volume	Ability to Implement	Cost	Notes
BD1 CDF	Only North Sump remains long-term concern HIGH	Some short-term exposure for workers MODERATE	Limited volume reduction since PAH-impacted sediment is contained LOW	Requires construction of in-water berm MODERATE	$9.6 M Mechanical $9.5 M Hydraulic	Contains all impacted sediment and NAPL except North Sump
BD2 Nearshore Containment	North Sump and Quendall remain as long-term concerns MODERATE	Some short-term exposure for workers MODERATE	Significant PAH volume reduction MODERATE	Requires placement of containment area in-water MODERATE	$11.1 M Mechanical $11.3 M Hydraulic	Some NAPL remains beyond wall at North Sump and Quendall
BD3 Dredging	Only North Sump remains long-term concern HIGH	Some short-term exposure for workers MODERATE	Near complete PAH volume reduction HIGH	Requires extensive dredging in the Quendall nearshore MODERATE	$13.5 M Mechanical $13.7 M Hydraulic	Removes all impacted sediment NAPL remains at North Sump and Quendall

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This alternative was rated moderate in each evaluation category. There is some volume reduction due to upland destruction of contaminants in T-Dock and some Quendall nearshore sediments. Long-term effectiveness is less than Alternative BD1's since some subsurface DNAPL seeps will remain outside the containment wall in the Quendall nearshore. This alternative costs approximately $1.8 million more than Alternative BD1.

6.4.3 Alternative BD3 - Dredging

This alternative includes dredging and upland management of the Grey Zone, the T-Dock area, and the Quendall nearshore. Subsurface DNAPL seeps will remain in the Quendall nearshore area and the containment wall will be placed on the upland portion of the site. Dredging in the Quendall nearshore will be restricted to within the upper 6 ft of sediment; fill in this area will provide an effective cap for any remaining impacted soil.

This alternative ranks high for long-term effectiveness and volume reduction. More nearshore DNAPL remains uncontained relative to the other alternatives, but more destruction/detoxification occurs using this alternative. Short-term effectiveness and implementability are considered moderate. This alternative costs approximately $2.9 million more than Alternative BD2.

6.5 Evaluation of Site-Wide Remedial Actions

The four soil and groundwater alternatives and the three sediment and containment wall alternatives were then combined into 12 site-wide remedial alternatives. Costs and an evaluation of each of the remedial alternative components were presented above. Table 6-7 provides a summary evaluation and cost estimate for each of the site-wide alternatives. Figures 6-2 through 6-13 provide a conceptual interpretation of how the site will remain following implementation of each of the alternatives.

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Table 6-7 Summary Evaluation of Site-Wide Remedial Alternatives

Site-Wide Remedial Alternative	Long-Term Effectiveness	Short-Term Effectiveness	Reduction in Mobility, Toxicity and Volume	Ability to Implement	Cost
Alternative #1 - AC0 + BD1	Low High	High Moderate	Low Low	High Moderate	$18.6 M
Alternative #2 - AC0 + BD2	Low Moderate	High Moderate	Low Moderate	High Moderate	$20.0 M
Alternative #3 - AC0 + BD3	Low High	High Moderate	Low High	High Moderate	$23.3 M
Alternative #4 - AC1 + BD1	Low High	High Moderate	Low Low	High Moderate	$19.3 M
Alternative #5 - AC1 + BD2	Low Moderate	High Moderate	Low Moderate	High Moderate	$21.1 M
Alternative #6 - AC1 + BD3	Low High	High Moderate	Low High	High Moderate	$24 M
Alternative #7 - AC2 + BD1	Moderate High	Moderate Moderate	Moderate Low	Moderate Moderate	$21.1 M
Alternative #8 - AC2 + BD2	Moderate Moderate	Moderate Moderate	Moderate Moderate	Moderate Moderate	$22.9 M
Alternative #9 - AC2 + BD3	Moderate High	Moderate Moderate	Moderate High	Moderate Moderate	$25.8 M
Alternative #10 - AC3 + BD1	High High	Low Moderate	High Low	Low Moderate	$23.3 M
Alternative #11 - AC3 + BD2	High Moderate	Low Moderate	High Moderate	Low Moderate	$25.1 M
Alternative #12 - AC3 + BD3	High High	Low Moderate	High High	Low Moderate	$28.0 M

NOTE: All remedies meet the minimum threshold of protectiveness.

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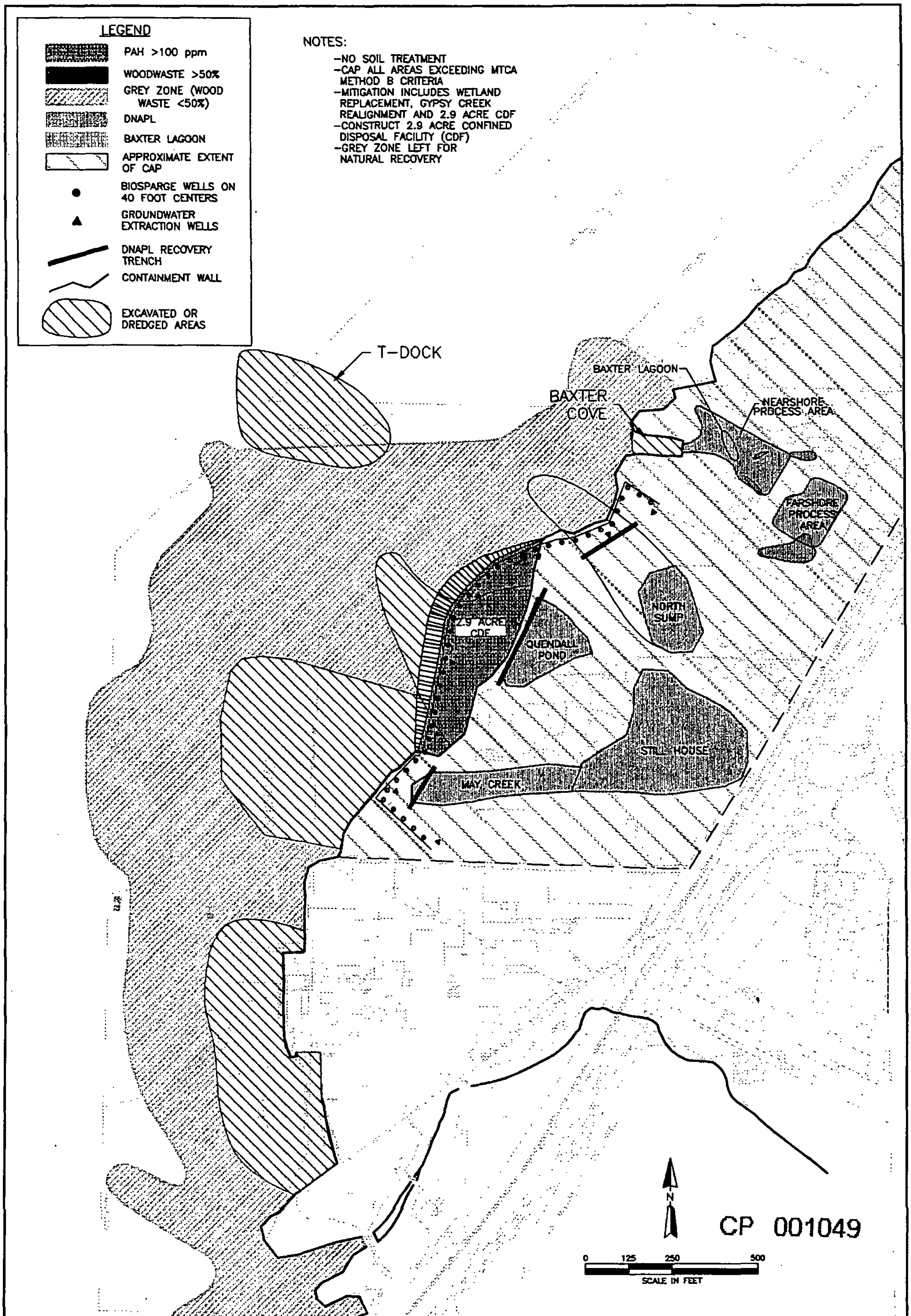


CP 001049

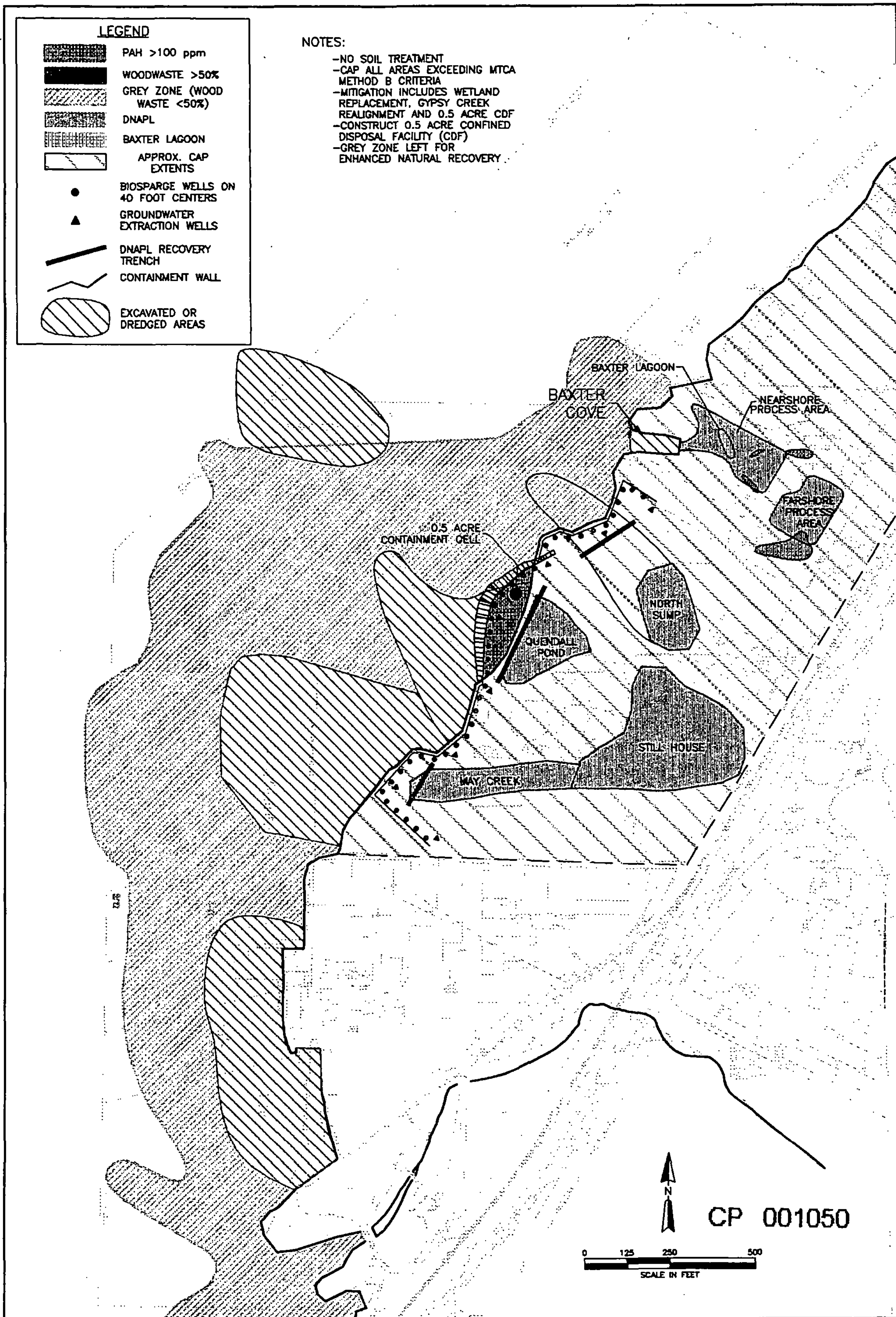
PORT QUENDALL COMPANY

3-2438-811

REMEDIAL ALTERNATIVE #1
PORT QUENDALL

RETEC

FIGURE 6-2



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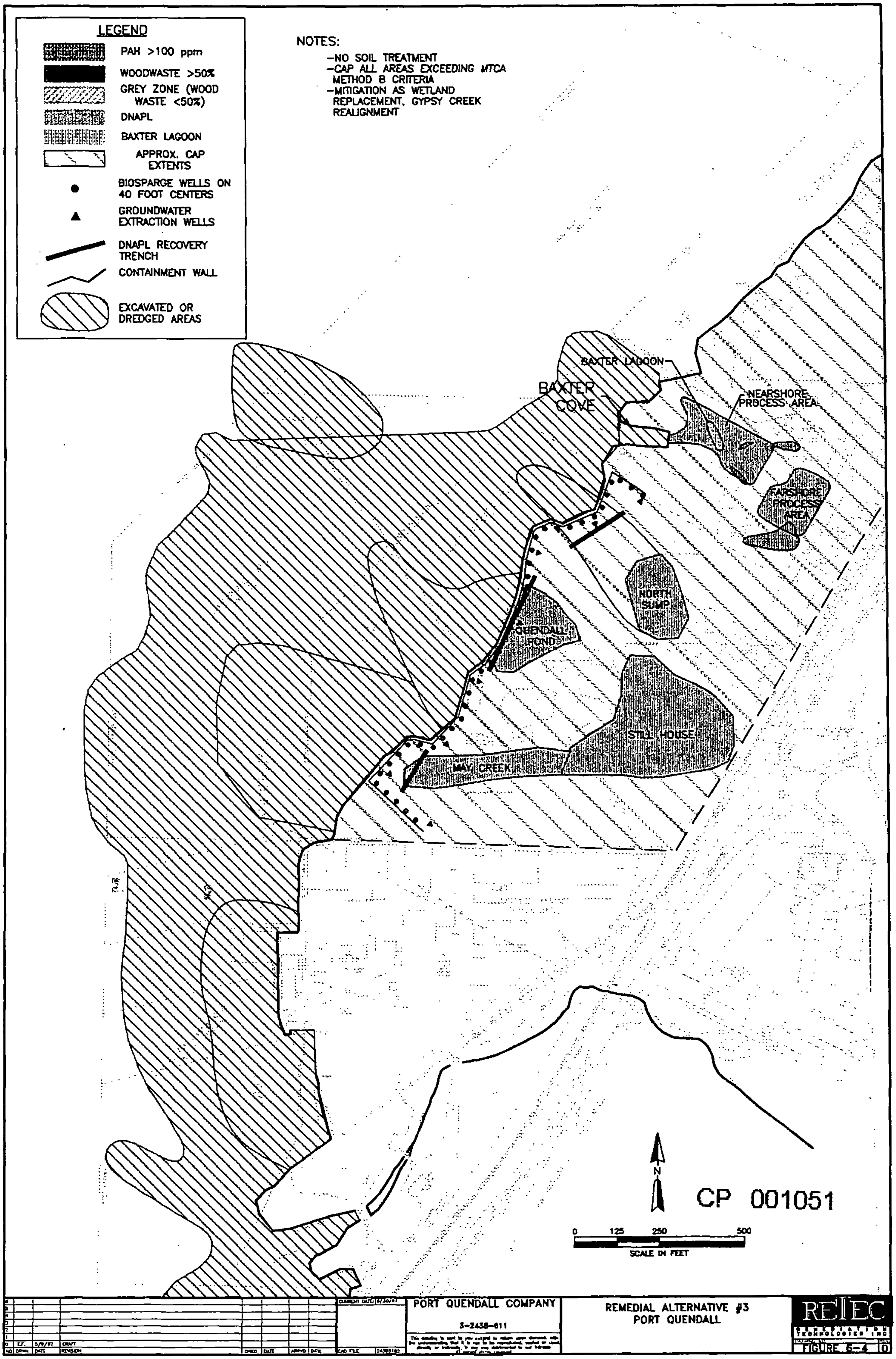
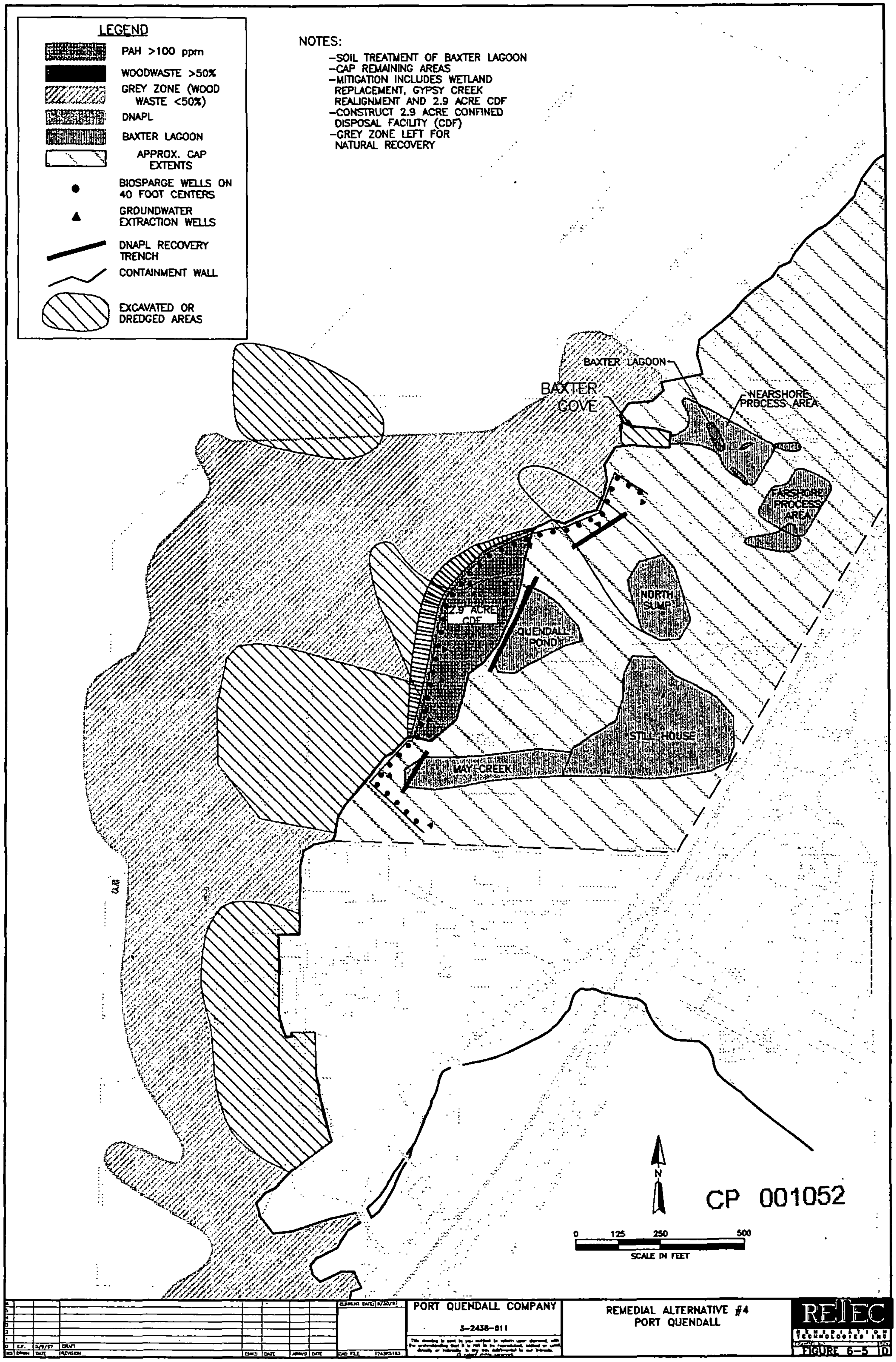
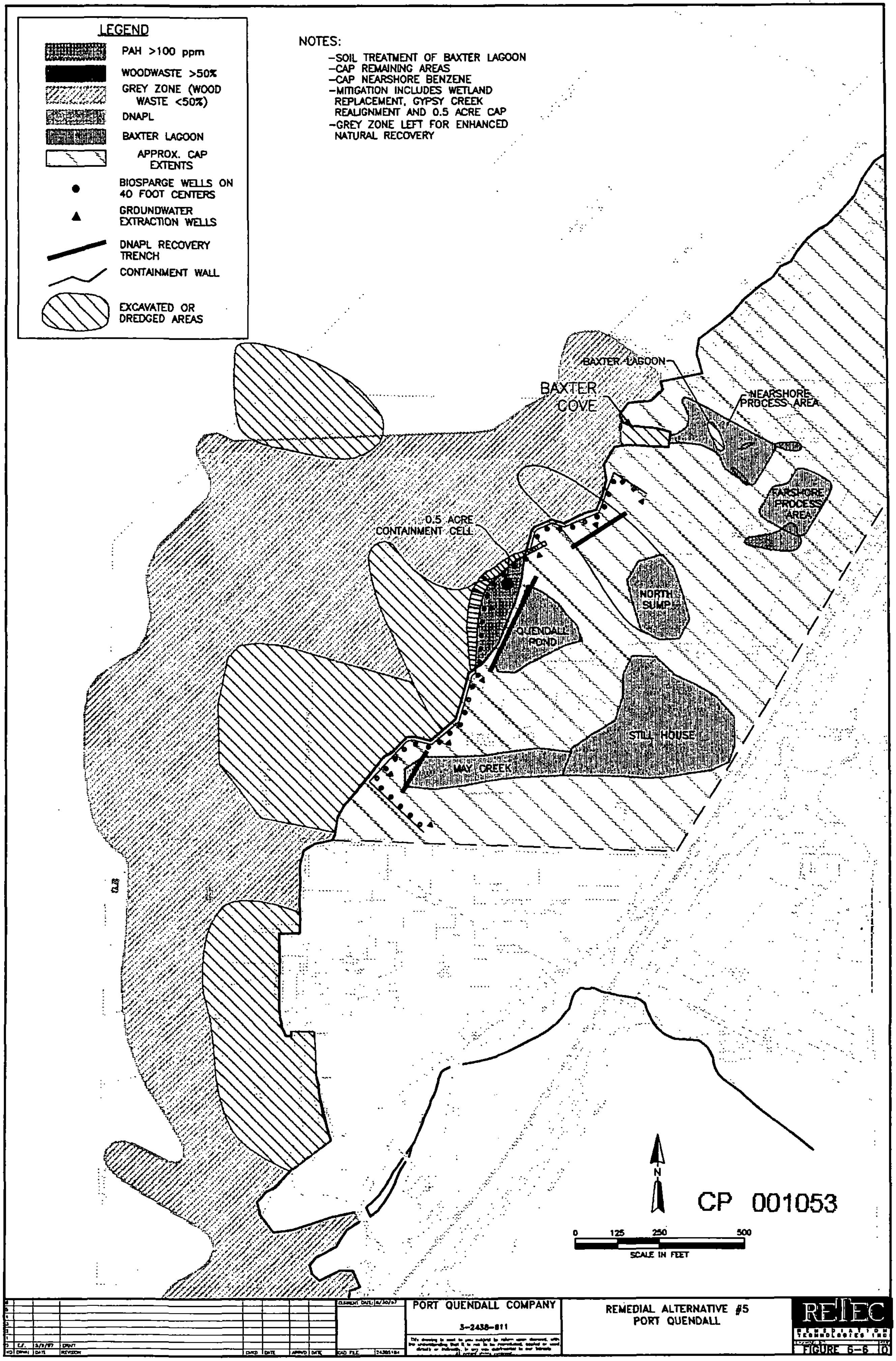
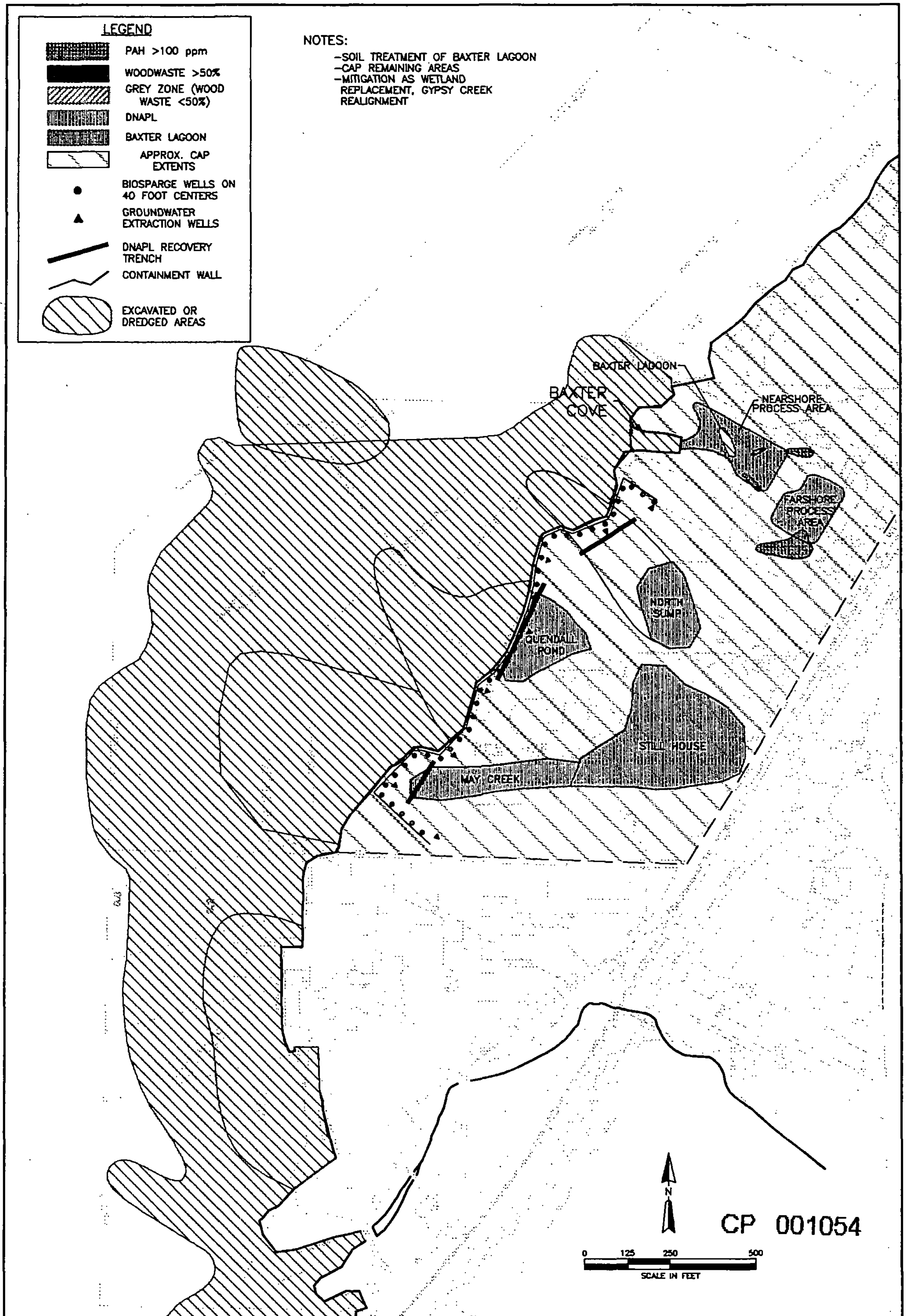
PORT QUENDALL COMPANY	REMEDIAL ALTERNATIVE #2 PORT QUENDALL	RETEC	FIGURE 6-3
3-2438-811			


LEGEND
PAH >100 ppm
WOODWASTE >50%
GREY ZONE (WOOD WASTE <50%)
DNAPL
BAXTER LAGOON
APPROX. CAP EXTENTS
BIOSPARGE WELLS ON 40 FOOT CENTERS
GROUNDWATER EXTRACTION WELLS
DNAPL RECOVERY TRENCH
CONTAINMENT WALL
EXCAVATED OR DREDGED AREAS
NOTES:
-NO SOIL TREATMENT
-CAP ALL AREAS EXCEEDING MTCA METHOD B CRITERIA
-MITIGATION AS WETLAND REPLACEMENT, GYPSY CREEK REALIGNMENT
BAXTER LAGOON
BAXTER COVE
NEARSHORE PROCESS AREA
FARSHORE PROCESS AREA
NORTH SUMP
QUENDALL POND
STILL HOUSE
MAY CREEK
N
0
125
250
500
SCALE IN FEET
PORT QUENDALL COMPANY
3-2436-611
REMEDIAL ALTERNATIVE #3
PORT QUENDALL
RETEC
FIGURE 6-4
0


LEGEND
PAH >100 ppm
WOODWASTE >50%
GREY ZONE (WOOD WASTE <50%)
DNAPL
BAXTER LAGOON
APPROX. CAP EXTENTS
BIOSPARGE WELLS ON 40 FOOT CENTERS
GROUNDWATER EXTRACTION WELLS
DNAPL RECOVERY TRENCH
CONTAINMENT WALL
EXCAVATED OR DREDGED AREAS
NOTES:
-SOIL TREATMENT OF BAXTER LAGOON
-CAP REMAINING AREAS
-MITIGATION INCLUDES WETLAND REPLACEMENT, GYPSY CREEK REALIGNMENT AND 2.9 ACRE CDF
-CONSTRUCT 2.9 ACRE CONFINED DISPOSAL FACILITY (CDF)
-GREY ZONE LEFT FOR NATURAL RECOVERY
BAXTER LAGOON
BAXTER COVE
NEARSHORE PROCESS AREA
FARSHORE PROCESS AREA
2.9 ACRE CDF
QUENDALL POND
NORTH SUMP
STILL HOUSE
MAY CREEK
N
CP 001052
0
125
250
500
SCALE IN FEET
PORT QUENDALL COMPANY
3-2436-811
REMEDIAL ALTERNATIVE #4
PORT QUENDALL
RETEC
REMEDIATION TECHNOLOGIES INC
FIGURE 6-5


LEGEND
PAH >100 ppm
WOODWASTE >50%
GREY ZONE (WOOD WASTE <50%)
DNAPL
BAXTER LAGOON
APPROX. CAP EXTENTS
BIOSPARGE WELLS ON 40 FOOT CENTERS
GROUNDWATER EXTRACTION WELLS
DNAPL RECOVERY TRENCH
CONTAINMENT WALL
EXCAVATED OR DREDGED AREAS
NOTES:
-SOIL TREATMENT OF BAXTER LAGOON
-CAP REMAINING AREAS
-CAP NEARSHORE BENZENE
-MITIGATION INCLUDES WETLAND REPLACEMENT, GYPSY CREEK REALIGNMENT AND 0.5 ACRE CAP
-GREY ZONE LEFT FOR ENHANCED NATURAL RECOVERY
BAXTER LAGOON
BAXTER COVE
NEARSHORE PROCESS AREA
FARSHORE PROCESS AREA
0.5 ACRE CONTAINMENT CELL
NORTH SUMP
QUENDALL POND
STILL HOUSE
MAY CREEK
N
CP 001053
0 125 250 500
SCALE IN FEET
C.F. 3/3/97 DRAFT
NO DRWN DATE REVISION
CHKD DATE APPVD DATE
CURRENT DATE: 6/30/97
CAD FILE 24385184
PORT QUENDALL COMPANY
3-2438-811
REMEDIAL ALTERNATIVE #5
PORT QUENDALL
RETEC
REMEDIATION TECHNOLOGIES INC
FIGURE 6-6 0



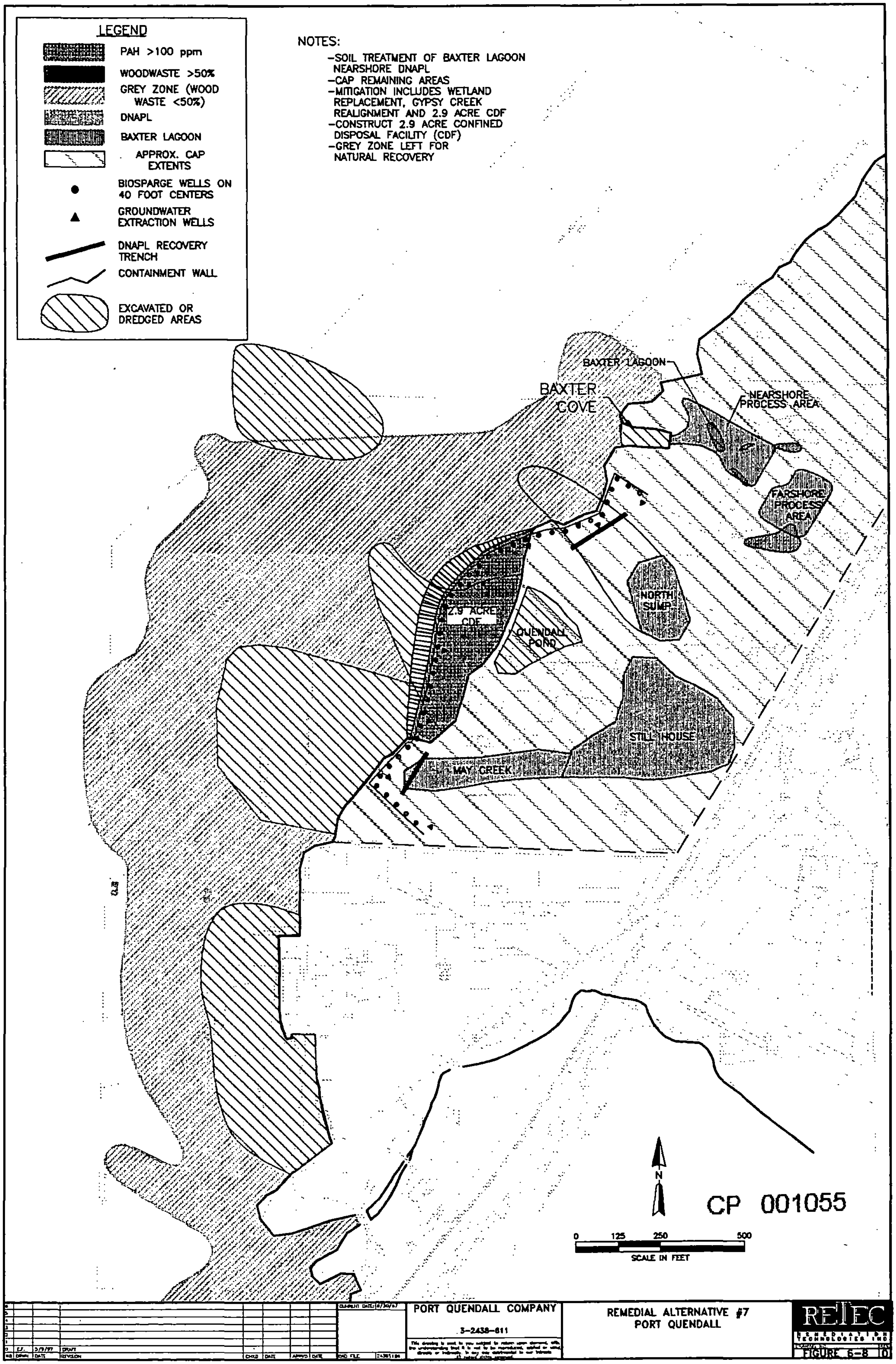
PORT QUENDALL COMPANY

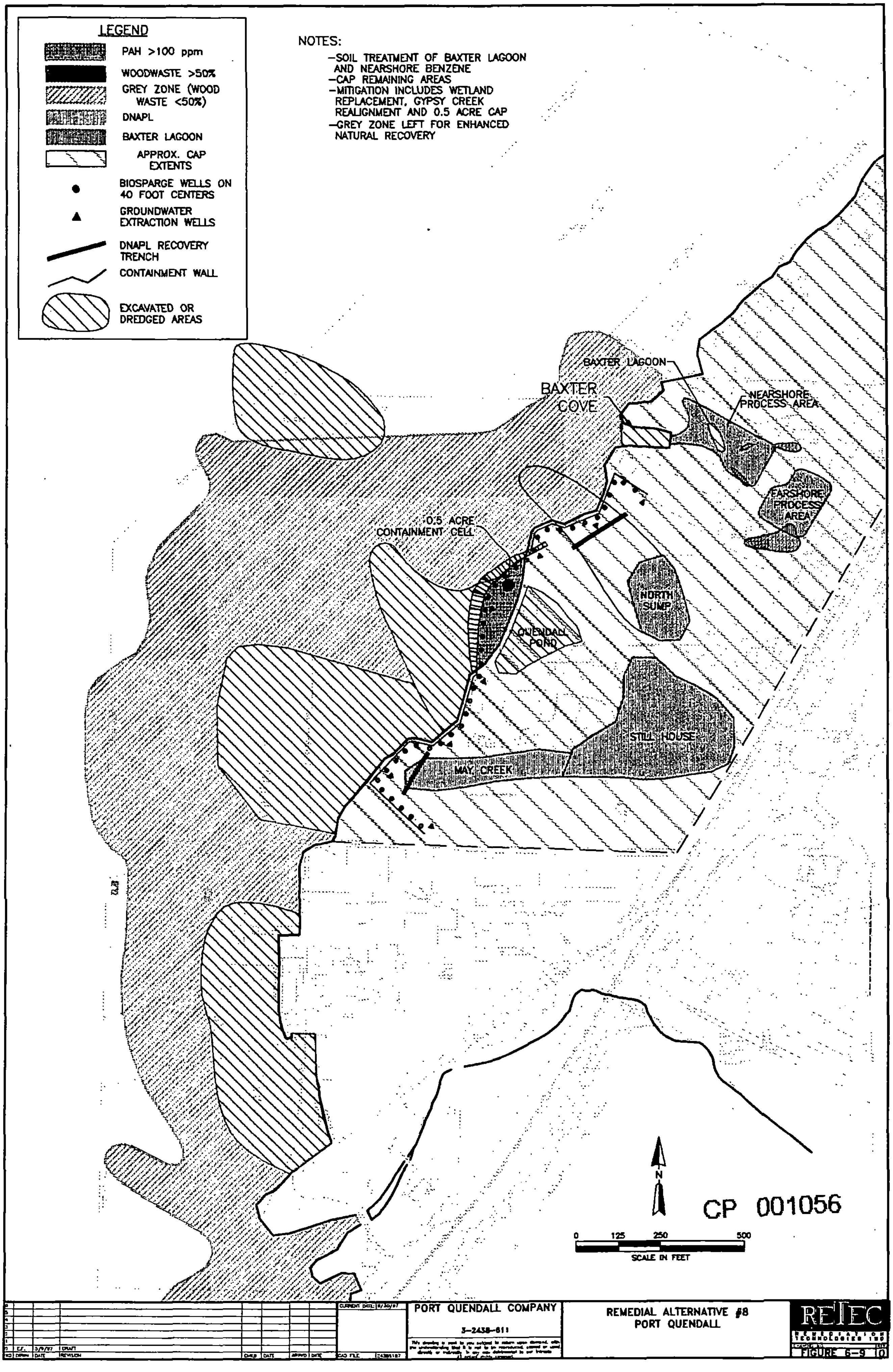
3-2438-011

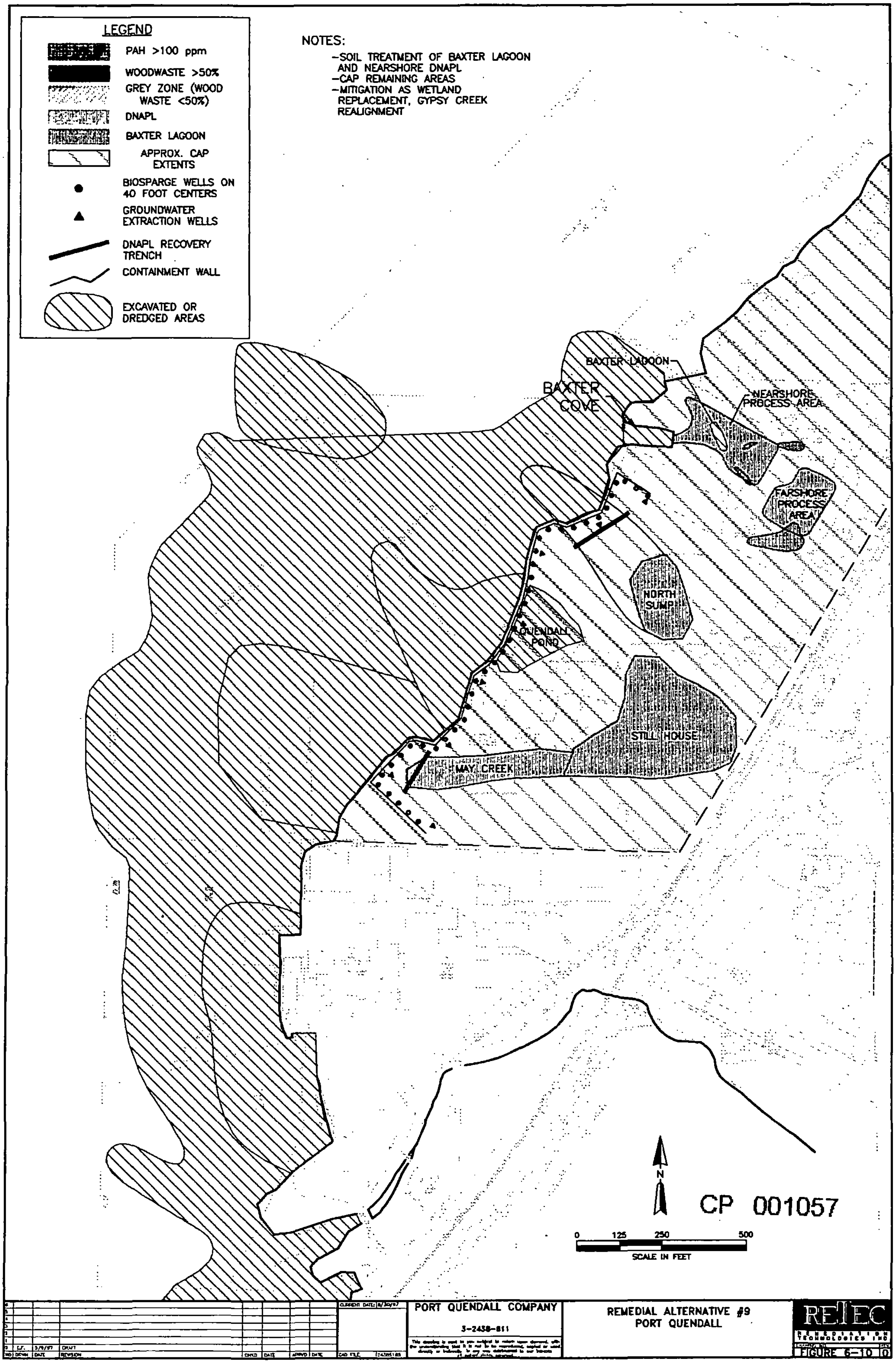
REMEDIAL ALTERNATIVE #6
PORT QUENDALL

RETEC

FIGURE 6-7

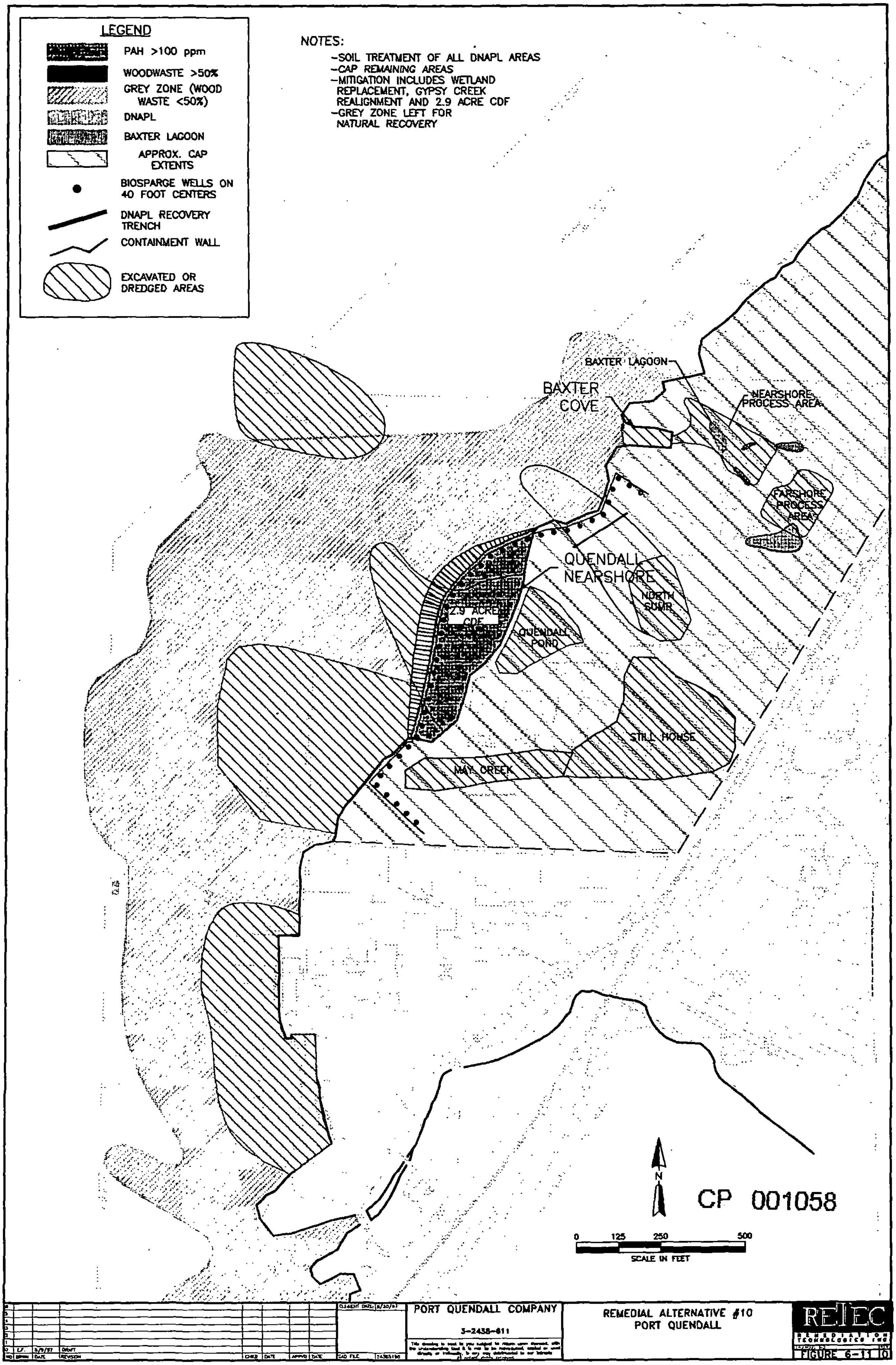

LEGEND
PAH >100 ppm
WOODWASTE >50%
GREY ZONE (WOOD WASTE <50%)
DNAPL
BAXTER LAGOON
APPROX. CAP EXTENTS
BIOSPARGE WELLS ON 40 FOOT CENTERS
GROUNDWATER EXTRACTION WELLS
DNAPL RECOVERY TRENCH
CONTAINMENT WALL
EXCAVATED OR DREDGED AREAS
NOTES:
-SOIL TREATMENT OF BAXTER LAGOON NEARSHORE DNAPL
-CAP REMAINING AREAS
-MITIGATION INCLUDES WETLAND REPLACEMENT, GYPSY CREEK REALIGNMENT AND 2.9 ACRE CDF
-CONSTRUCT 2.9 ACRE CONFINED DISPOSAL FACILITY (CDF)
-GREY ZONE LEFT FOR NATURAL RECOVERY
BAXTER LAGOON
BAXTER COVE
NEARSHORE PROCESS AREA
FARSHORE PROCESS AREA
2.9 ACRE CDF
QUENDALL POND
NORTH SUMP
STILL HOUSE
MAY CREEK
N
0 125 250 500
SCALE IN FEET
PORT QUENDALL COMPANY
3-2438-611
REMEDIAL ALTERNATIVE #7
PORT QUENDALL
RETEC
FIGURE 6-8

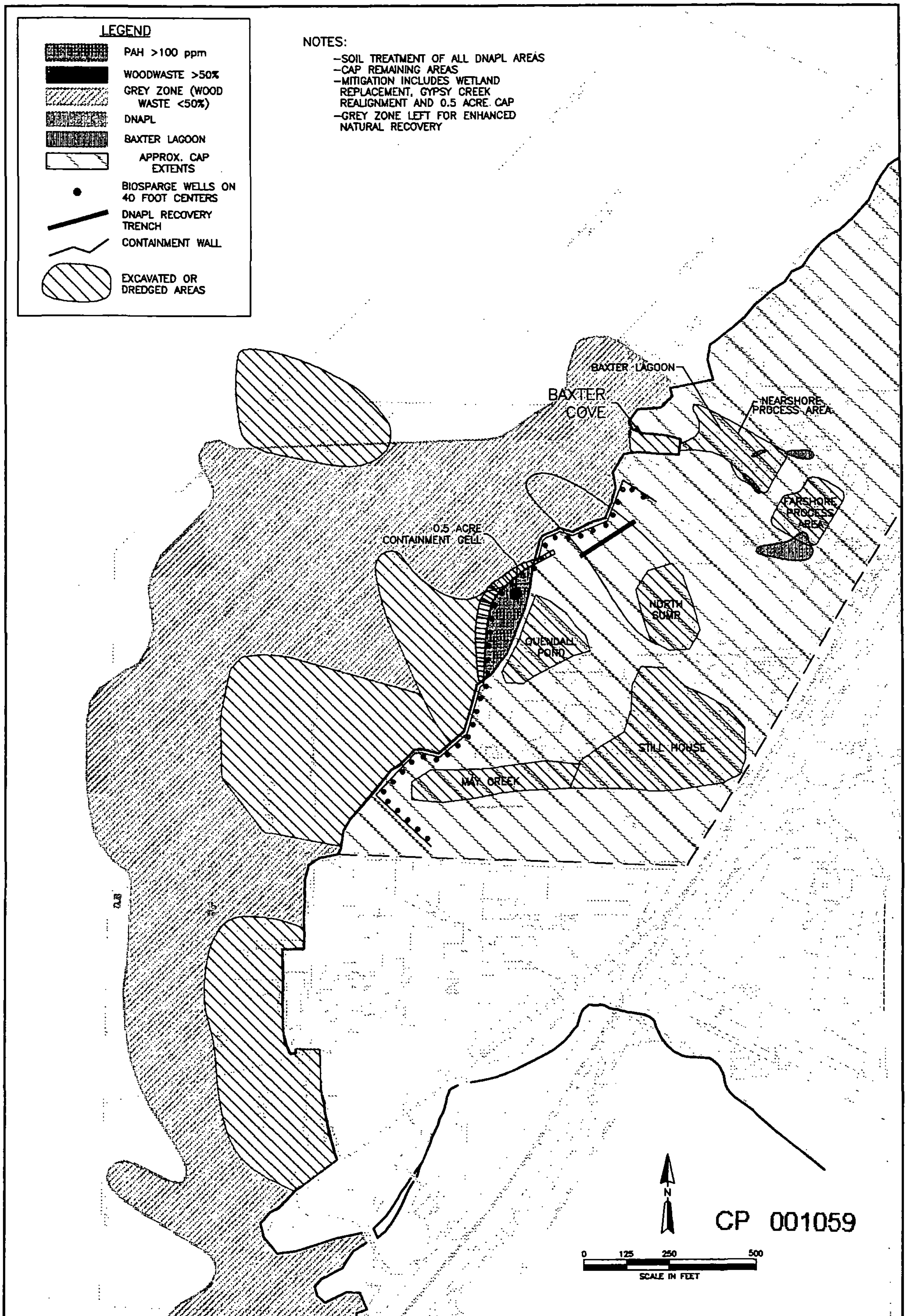

LEGEND
PAH >100 ppm
WOODWASTE >50%
GREY ZONE (WOOD WASTE <50%)
DNAPL
BAXTER LAGOON
APPROX. CAP EXTENTS
BIOSPARGE WELLS ON 40 FOOT CENTERS
GROUNDWATER EXTRACTION WELLS
DNAPL RECOVERY TRENCH
CONTAINMENT WALL
EXCAVATED OR DREDGED AREAS
NOTES:
-SOIL TREATMENT OF BAXTER LAGOON AND NEARSHORE BENZENE
-CAP REMAINING AREAS
-MITIGATION INCLUDES WETLAND REPLACEMENT, GYPSY CREEK REALIGNMENT AND 0.5 ACRE CAP
-GREY ZONE LEFT FOR ENHANCED NATURAL RECOVERY
BAXTER LAGOON
BAXTER COVE
NEARSHORE PROCESS AREA
FARSHORE PROCESS AREA
0.5 ACRE CONTAINMENT CELL
NORTH SUMP
QUENDALL POND
STILL HOUSE
MAY CREEK
N
0
125
250
500
SCALE IN FEET
CP 001056
PORT QUENDALL COMPANY
3-2438-611
REMEDIAL ALTERNATIVE #8
PORT QUENDALL
RETEC
FIGURE 6-9



LEGEND
PAH >100 ppm
WOODWASTE >50%
GREY ZONE (WOOD WASTE <50%)
DNAPL
BAXTER LAGOON
APPROX. CAP EXTENTS
BIOSPARGE WELLS ON 40 FOOT CENTERS
GROUNDWATER EXTRACTION WELLS
DNAPL RECOVERY TRENCH
CONTAINMENT WALL
EXCAVATED OR DREDGED AREAS
NOTES:
-SOIL TREATMENT OF BAXTER LAGOON AND NEARSHORE DNAPL
-CAP REMAINING AREAS
-MITIGATION AS WETLAND REPLACEMENT, GYPSY CREEK REALIGNMENT
BAXTER LAGOON
BAXTER COVE
NEARSHORE PROCESS AREA
FARSHORE PROCESS AREA
NORTH SUMP
QUENDALL POND
STILL HOUSE
MAY CREEK
N
0
125
250
500
SCALE IN FEET
PORT QUENDALL COMPANY
3-2438-811
REMEDIAL ALTERNATIVE #9
PORT QUENDALL
RETEC
REMEDIATION TECHNOLOGIES INC
FIGURE 6-10

CP 001057


LEGEND
PAH >100 ppm
WOODWASTE >50%
GREY ZONE (WOOD WASTE <50%)
DNAPL
BAXTER LAGOON
APPROX. CAP EXTENTS
BIOSPARGE WELLS ON 40 FOOT CENTERS
DNAPL RECOVERY TRENCH
CONTAINMENT WALL
EXCAVATED OR DREDGED AREAS
NOTES:
-SOIL TREATMENT OF ALL DNAPL AREAS
-CAP REMAINING AREAS
-MITIGATION INCLUDES WETLAND REPLACEMENT, GYPSY CREEK REALIGNMENT AND 2.9 ACRE CDF
-GREY ZONE LEFT FOR NATURAL RECOVERY
BAXTER LAGOON
BAXTER COVE
NEARSHORE PROCESS AREA
FARSHORE PROCESS AREA
QUENDALL NEARSHORE
NORTH SUMP
2.9 ACRE CDF
QUENDALL POND
STILL HOUSE
MAY CREEK
N
0 125 250 500
SCALE IN FEET
PORT QUENDALL COMPANY
3-2438-611
REMEDIAL ALTERNATIVE #10
PORT QUENDALL
RETEC
FIGURE 6-11



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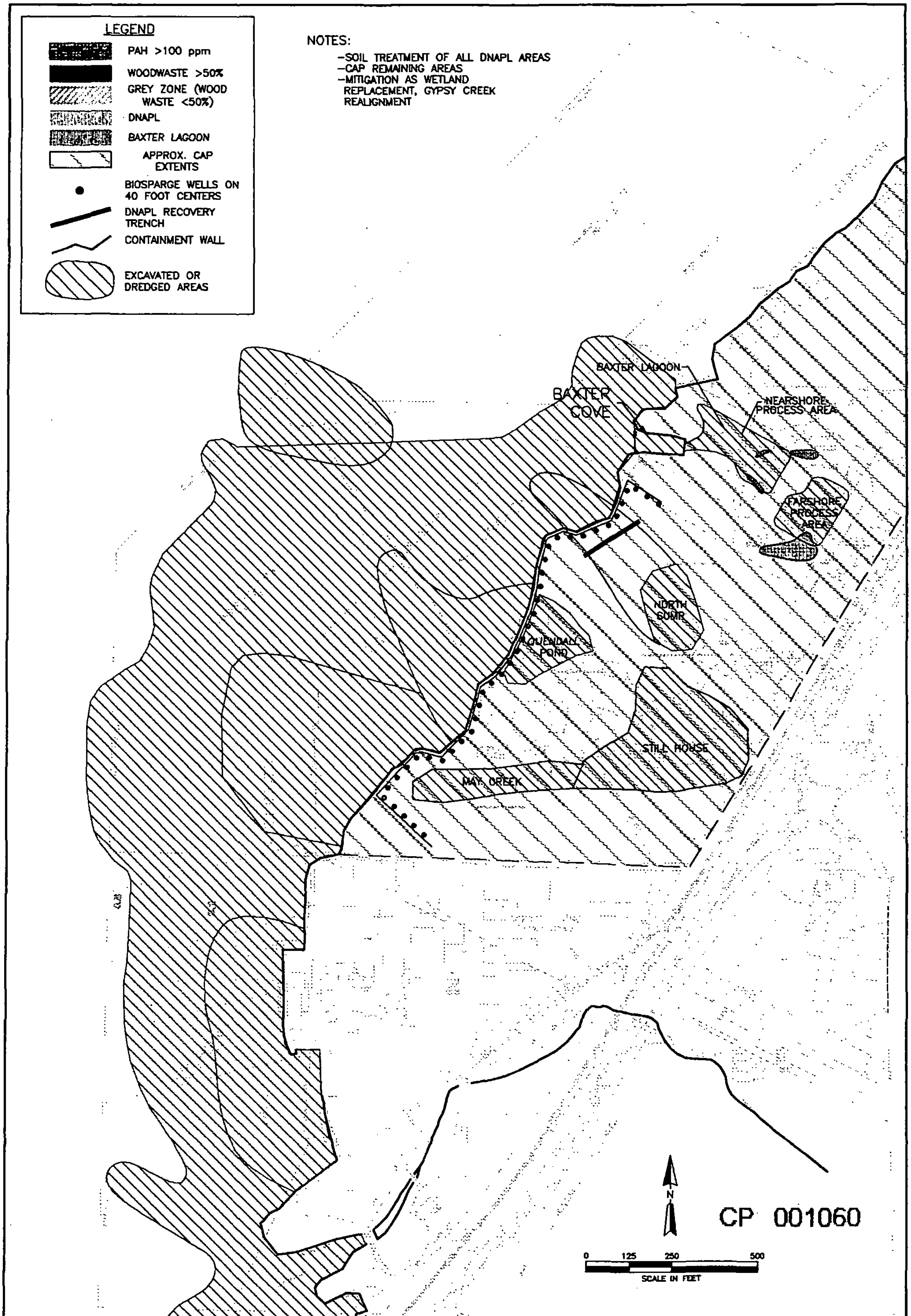
PORT QUENDALL COMPANY

3-2438-611

REMEDIAL ALTERNATIVE #11
PORT QUENDALL

RETEC
REMEDIATION TECHNOLOGIES INC

FIGURE 6-12



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CURRENT DATE: 6/30/97

PORT QUENDALL COMPANY

3-2438-611

REMEDIAL ALTERNATIVE #12
PORT QUENDALL

RETEC

FIGURE 6-13

7 Summary and Discussion

This Feasibility Study is subject to the disclaimer found in Section 1.3. The study was prepared for the Port Quendall Company as part of the due diligence related to the potential purchase of the J.H. Baxter, Quendall Terminals, Pan Abode and Barbee Mill properties. The Baxter and Quendall properties currently require cleanup under the Washington State Model Toxics Control Act (MTCA). The primary focus of the FS was to evaluate cleanup alternatives for those two properties. In addition, Ecology expressed concern regarding the potential presence of wood waste in harbor area sediments adjacent to the Barbee Mill property. After consultation with and approval by the Barbee Mill owners and the Department of Natural Resources, a discussion of management options for Barbee sediments was included in this FS.

The purpose of this Feasibility Study was to quantify the range of costs associated with cleaning up the properties in a manner which is protective of human health and the environment and which is consistent with the proposed Port Quendall redevelopment plans. A focused set of remedial alternatives was developed after extensive consultation with Ecology and other resource agencies. These alternatives were then used to develop a range of costs for the cleanup of the subject properties.

All the alternatives presented in the FS meet the minimum threshold requirements of complying with cleanup levels and ARARs and being protective of human health and the environment. The alternatives vary in the way in which this level of protection is achieved. Some alternatives rely predominantly on containment remedies (i.e., soil capping), whereas other alternatives rely predominantly on removal and treatment alternatives (i.e., soil removal and thermal treatment). The estimated costs developed in the FS ranged from $18.6 million to $28 million, with the more expensive alternatives involving a greater amount of contaminant removal.

Alternatives which involve removal of all contaminated soils and sediments exceeding cleanup levels were determined in the remedy screening process to be technically infeasible and not cost effective. As a result, all of the alternatives presented in the detailed evaluation (Section 6) assume that institutional controls, including deed restrictions and long-term monitoring, will be required.

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7.2 Pro-Forma Analysis

RETEC developed a "most probable" least cost associated with site cleanup for the Baxter and Quendall properties and for management of sediments adjacent to Barbee Mill. The remedies included in the "most probable" cost are based on the work completed to date and based on opinions expressed by Ecology and the other resource agencies during the Port Quendall project meetings. The use of other remedies may be equally protective and appropriate for other development assumptions, or after additional testing or regulatory analysis. Uncertainties associated with the cost estimate were identified and bounded by an upper cost range as described below for each of the properties.

J.H. Baxter

Table 7-1 presents the cost estimate for the Baxter site. Detailed backup for each of the line items is included in Appendix A of this report. For Baxter the assumed remedy includes the following:

- Off-site incineration of Baxter Lagoon sediments (assumes these materials are designated as K001 wastes)
- On-site thermal treatment of contaminated soil from identified source areas
- Capping of soil areas which exceed MTCA Method B direct contact cleanup levels
- Excavation and on-site thermal treatment of contaminated sediments from Baxter Cove
- Wetland mitigation
- Long-term groundwater monitoring and institutional controls

This remedy is based on the use of the site for both commercial and residential uses. The total cost of this remedy is estimated at $5.7 million. The most significant cost uncertainties associated with this remedy are related to the volume of contaminated soils requiring excavation and treatment. To the extent that the final cleanup will require compliance with a concentration-based "remediation level" for any removal action, there is a significant risk that volumes and costs could increase. We have added an uncertainty factor of 1.7 to all of the predicted excavation volumes to develop an upper range cost estimate for this alternative. The use of an area-based remediation action would decrease this risk.

Two additional risk factors are whether a backup groundwater extraction and treatment system will be required, and what groundwater extraction rates will be associated with such a system. Based on the results of modeling work conducted by RETEC for the Baxter property, we believe that natural attenuation will be

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Table 7-1 Remedial Action Cost Summary, Baxter and North Baxter Properties

	Probable Least Cost	Probable Upper Cost
Mobilization/Site Preparation	444,500	508,000
Demolition	189,230	189,230
Soil Treatment (Thermal Desorption)		
Hazardous Waste Excavation and Incineration	702,945	1,555,052
Baxter Nearshore	1,513,787	2,853,148
Baxter Farshore	483,108	952,398
Drip Tracks	223,520	426,466
Barker Area	84,455	144,717
Capping		
Baxter Nearshore	123,017	136,843
Baxter Farshore	100,459	114,285
Remainder of Method B Exceedance Areas	657,449	671,275
Sediment - Baxter Cove	142,056	247,469
Mitigation	508,000	508,000
Institutional Controls & Monitoring	532,396	1,002,619
SUBTOTAL (Soil Removal and Capping)	$5,700,000	$9,300,000
Groundwater Extraction & Treatment	$1,148,405	$3,165,814
TOTAL COST	$6,900,000	$12,500,000

NOTE: Estimate assumes clean fill is still available at no cost from Cedar River dredging

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effective at meeting groundwater cleanup requirements after the soil removal actions described in the "most probable" scenario have been conducted. However, there is limited precedent for agency acceptance of this type of remedy at other wood treating sites in the state. Therefore, we have included the costs of a groundwater extraction and treatment system as a contingency for this property.

After all of the uncertainty factors have been included, the upper bound on the Baxter remediation costs is estimated to be $12.5 million.

Quendall Terminals

For the Quendall Terminal property, two estimates were developed based on the use of the site for a "low density" commercial development and a "high density" commercial/residential development. These two estimates are shown in Table 7-2. Detailed backup for these costs is included in Appendix A of this report.

The first Quendall estimate assumes that the site would be used for a "low impact" development, which could include commercial uses in two-story structures. Under this scenario, the need for extensive piling in areas of contamination could be minimized, such that aggressive removal of DNAPL impact soils would not be required. For sediments, this alternative assumes that PAH-contaminated sediments at the T-Dock are dredged and consolidated in a confined disposal facility in the Quendall inner harbor area, sediments with >50% wood waste are dredged and recycled and that the sediment "grey zone" is treated through enhanced natural recovery.

The estimated cost of the "low impact" alternative is $16.8 million. Cost uncertainties associated with this alternative are related to the costs of DNAPL recovery and the volumes and costs associated with impacted sediment removal. With these contingencies, the upper cost is assumed to be $18.7 million.

The "high impact" scenario for the Quendall property assumes that property development will involve buildings with deep-piling foundations, which could be used for residential and commercial purposes. Aggressive excavation and on-site thermal treatment of DNAPL-impacted soils are assumed under this alternative. Based on this extensive removal action, the need for DNAPL recovery is greatly reduced, the costs of capping are reduced, and a backup groundwater extraction system is omitted. For sediments, this alternative assumes that all impacted sediments are removed by dredging, including PAH-contaminated sediments at both the T-Dock and nearshore areas, the sediments containing >50 percent wood waste and also the grey zone sediments. Under this alternative, the

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RETEC

Table 7-2 Remedial Action Cost Summary, Quendall Terminals Property

	Low Impact Development		High Impact Development	
	Probable Least Cost	Probable Upper Cost	Probable Least Cost	Probable Upper Cost
SOIL AND GROUNDWATER				
Soil Treatment	$0	$0	$6,886,643	$12,767,538
Mobilization/Site Prep			506,674	570,174
Quendall Pond			1,862,452	3,419,617
Former May Creek			1,306,380	2,395,655
North Sump			908,208	1,754,316
Still House			2,302,929	4,627,777
DNAPL Recovery	$1,868,320	$1,924,221	$941,952	$969,903
Mobilization/Site Preparation	63,500	63,500	63,500	63,500
North Sump	878,452	906,403	878,452	906,403
Quendall Pond	463,184	477,159		
Former May Creek	463,184	477,159		
Cap	$2,050,676	$2,050,676	$452,025	$452,025
Mobilization/Site Preparation	63,500	63,500	63,500	63,500
Quendall Pond	120,203	120,203		
Former May Creek	134,097	134,097		
North Sump	113,876	113,876		
Still House	371,074	371,074		
Other Method B Exceedances	1,247,926	1,247,926	388,525	388,525
Groundwater	$5,305,130	$5,305,130	$1,973,726	$1,973,726
Biosparging	999,167	999,167	999,167	999,167
Groundwater Extraction	3,331,404	3,331,404		
Institutional Controls/Monitoring	974,559	974,559	974,559	974,559
Subtotal (Soil and Groundwater)	$9,224,125	$9,280,027	$10,254,346	$16,163,192
SEDIMENT AND CONTAINMENT WALL				
Sediment Remediation	$5,470,150	$7,319,163	$10,845,916	$18,381,900
Mobilization/Site Preparation	468,600	468,600	468,600	468,600
Remove/Recycle Wood Waste	2,201,595	3,305,351	2,201,595	3,305,351
Grey Zone Dredging			3,603,727	5,992,146
Grey Zone Natural Recovery	254,983	254,983		
CDF, Dredge T-Dock & Nrshr	2,544,972	3,290,228		
T-Dock Dredging			1,817,829	3,387,749
Nearshore Dredging (6' max)			2,754,165	5,228,054
Mitigation	$1,016,000	$1,016,000	$508,000	$508,000
Wetland Replacement	508,000	508,000	508,000	508,000
For CDF (2.9 acres)	508,000	508,000		
Containment Wall	$1,327,500	$1,327,500	$1,173,333	$1,255,000
Upland Wall			1,173,333	1,255,000
CDF Outer Wall	1,327,500	1,327,500		
Subtotal Cost (Sediment and Containment Wall)	$7,813,650	$9,662,663	$12,527,249	$20,144,900
TOTAL COST	$17,000,000	$19,000,000	$23,000,000	$36,000,000

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confined disposal facility for sediments has been removed and the containment wall is located on the upland portion of the site.

The estimated cost of the "high impact" alternative is $23.0 million. However, there are substantial cost uncertainties related to this alternative. These uncertainties are associated with the volumes of impacted soil which are removed, the costs of DNAPL recovery and the costs of conducting the sediment removal action. There is still significant work to be completed with the regulatory agencies to develop a consensus on remedial approaches to the wood waste and contaminated sediments found off shore of Quendall. With these uncertainties, the upper cost is assumed to be $36.6 million for this alternative.

It should be noted that the costs for the Quendall Terminals includes the costs of managing sediments containing wood waste that are offshore of the Barbee Mill property. This is consistent with the development of the alternatives presented in the FS.

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Appendix A

Detailed Cost Estimates

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Table A-1 Soil and Groundwater (AC) Remedial Alternatives Cost Estimates

	AC0 - No Soil Treatment		AC1 - Hazardous Waste		AC2 - Nearshore DNAPL		AC3 - All DNAPL	
	Probable Least Cost	Probable Upper Cost	Probable Least Cost	Probable Upper Cost	Probable Least Cost	Probable Upper Cost	Probable Least Cost	Probable Upper Cost
Soil Treatment	$0	$0	$702,945	$1,555,052	$3,072,071	$5,544,843	$9,894,458	$18,699,320
Mobilization/Site Prep					506,674	570,174	506,674	570,174
Hazardous Waste			702,945	1,555,052	702,945	1,555,052	702,945	1,555,052
Quendall Pond					1,862,452	3,419,617	1,862,452	3,419,617
Former May Creek							1,306,380	2,395,655
Baxter Nearshore							1,513,787	2,853,148
North Sump							908,208	1,754,316
Still House							2,302,929	4,627,777
Baxter Farshore							483,108	952,398
Baxter Farshore							307,975	571,183
DNAPL Recovery	$1,868,320	$1,924,221	$1,868,320	$1,924,221	$1,405,136	$1,447,062	$941,952	$969,903
Mobilization/Site Preparation	63,500	63,500	63,500	63,500	63,500	63,500	63,500	63,500
North Sump	878,452	906,403	878,452	906,403	878,452	906,403	878,452	906,403
Quendall Pond	463,184	477,159	463,184	477,159				
Former May Creek	463,184	477,159	463,184	477,159	463,184	477,159		
Cap	$2,931,601	$2,973,079	$2,931,601	$2,973,079	$2,811,398	$2,852,876	$1,968,875	$1,982,701
Mobilization/Site Preparation	63,500	63,500	63,500	63,500	63,500	63,500	63,500	63,500
Quendall Pond	120,203	120,203	120,203	120,203				
Former May Creek	134,097	134,097	134,097	134,097	134,097	134,097		
Baxter Nearshore	123,017	136,843	123,017	136,843	123,017	136,843		
North Sump	113,876	113,876	113,876	113,876	113,876	113,876		
Still House	371,074	371,074	371,074	371,074	371,074	371,074		
Baxter Farshore	100,459	114,285	100,459	114,285	100,459	114,285		
Other Method B Exceedances	1,905,375	1,919,201	1,905,375	1,919,201	1,905,375	1,919,201	1,905,375	1,919,201
Groundwater	$5,305,130	$5,305,130	$5,305,130	$5,305,130	$5,305,130	$5,305,130	$1,973,726	$1,973,726
Biosparging	999,167	999,167	999,167	999,167	999,167	999,167	999,167	999,167
Groundwater Extraction	3,331,404	3,331,404	3,331,404	3,331,404	3,331,404	3,331,404		
Institutional Controls/Monitoring	974,559	974,559	974,559	974,559	974,559	974,559	974,559	974,559
TOTAL COST	$10,100,000	$10,200,000	$10,800,000	$11,800,000	$12,600,000	$15,100,000	$14,800,000	$23,600,000

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Table A-2 Sediment and Containment Wall (BD) Remedial Alternatives Cost Estimates

	BD1 - CDF (2.9 acres)		BD2 - Containment (0.5 acres)		BD3 - Nearshore Removal	
	Probable Least Cost	Probable Upper Cost	Probable Least Cost	Probable Upper Cost	Probable Least Cost	Probable Upper Cost
Sediment Remediation	$5,630,206	$7,584,631	$7,551,655	$12,435,492	$11,005,972	$18,647,369
Mobilization/Site Preparation	486,600	486,600	486,600	486,600	486,600	486,600
Remove/Recycle Wood Waste	2,201,595	3,305,351	2,201,595	3,305,351	2,201,595	3,305,351
Grey Zone Dredging					3,603,727	5,992,146
Grey Zone Natural Recovery	254,983	254,983				
Grey Zone Enhanced Recovery			462,530	462,530		
CDF, Dredge T-Dock & Nrshr	2,544,972	3,290,228				
Containment, Dredge Nearshore			2,441,045	4,545,793		
T-Dock Dredging			1,817,829	3,387,749	1,817,829	3,387,749
Nearshore Dredging (6' max)					2,754,165	5,228,054
Baxter Cove	142,056	247,469	142,056	247,469	142,056	247,469
Mitigation	$1,524,000	$1,524,000	$1,524,000	$1,524,000	$1,016,000	$1,016,000
Wetland Replacement	508,000	508,000	508,000	508,000	508,000	508,000
Gypsy Creek Realignment	508,000	508,000	508,000	508,000	508,000	508,000
For CDF (2.9 acres)	508,000	508,000				
For Containment (0.5 acres)			508,000	508,000		
Containment Wall	$1,327,500	$1,327,500	$1,256,250	$1,256,250	$1,173,333	$1,173,333
Upland Wall					1,173,333	1,173,333
Nearshore Wall			1,256,250	1,256,250		
CDF Outer Wall	1,327,500	1,327,500				
TOTAL COST	$8,500,000	$10,400,000	$10,300,000	$15,200,000	$13,200,000	$20,800,000

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PROBABLE LEAST SITE REMEDIATION COST ESTIMATE
BAXTER AND NORTH BAXTER PROPERTIES
PORT QUENDALL DEVELOPMENT

Material Handling Assumptions:	**Excavation**	**Surface Area**	**Probable Upper Values**
Hazardous Waste (Baxter Lagoon)	**500** cy	2,180 sf	**850** cy
Baxter Nearshore	**13,620** cy	33,060 sf	**23154** cy
Baxter Farshore	**4,800** cy	26,230 sf	**8160** cy
Drip Tracks	**2,000** cy		**3400** cy
Barker	**500** cy		**850** cy
Baxter Cove	**900** cy		**1530** cy
Capping Area Assumptions:			
Total Area Exceeding Method B	700,000 sf		
Area to be Capped with Liner and Fill	59,290 sf		
Area Covered by Development Features	50%		
Area to be Capped with 3 feet of Clean Fill	335,178 sf		
Cost Estimating Parameters & Methodology:			
Interest Rate	8.0%		
Soil Density (in situ)	1.40 tons/cy		
<u>Excavation and Backfilling</u>			
Mobilization	$100,000		
Excavation/Stockpiling	$10 per cy		
Excavation/Backfill Rate	1,000 cy per day		
Dewatering System Install	**$100,000** ls		**$150,000** ls
Water Treatment	**$0.01** per gallon		**$0.02** per gallon
Temporary Steel Piling	$15 per sf		
Backfill and Compact On-Site Soil	$7 per cy		
Upland Handling	$5 per cy		
<u>Baxter Cove Excavation</u>			
Initial Moisture Content (% mass)	55%		
Moisture Content After Dewatering	30%		
Excavation	$10		
Backfill	$8		
<u>Capping</u>			
Clean Fill Capping	$1.00 per sf		1.0% of capital cost
Liner and Fill Capping	$2.00 per sf		1.0% of capital cost
Offloading Crane Mobilization	$50,000		
Clean Sediment Offloading Rate	1,000 cy per shift		
Clean Sediment Offload Shift Rate	$3,500 per shift		
<u>Soil Treatment</u>			
On-Site Thermal Treatment	$100,000 mobilization, plus		
	$40 per ton		**$50** per ton
Off-Site Incineration	**$750** per ton		**$1,000** per ton
<u>Analytical Costs per Excavation Area</u>			
Excavation Confirmation	$20,000 LS	Soil Treatment QA	$10,000 LS
<u>Groundwater Extraction</u>			
Upgrade Dewatering System	**$100,000**		**$200,000**
Extraction Wells, Piping, etc. (6" PVC x 40 feet)	$25,000 each		
Number of Extraction Wells	**4**		**8**
Extraction Rate	**25** gpm		**50** gpm
Groundwater Treatment	**$10** per 1000 gal		**$15** per 1000 gal
<u>Groundwater Monitoring</u>			
Monitoring Wells	$10,000 ea		
Number of Monitoring Wells	**4**		**10**
Plans	$20,000		
Sampling and Analytical	**$25,000** per year		**$50,000** per year
Reporting	**$10,000** per year		**$20,000** per year
<u>Institutional Controls</u>			
Public Education Program	$20,000 originally, plus		$1,000 per year
Maintaining O&M Plans	$8,000 originally, plus		$800 per year
Deed Restrictions	$5,000 originally		
<u>Engineering, Procurement & Construction Management</u>	12% of capital		
<u>Contingency</u>	15% of capital		

COST ESTIMATE FOR MOBILIZATION/SITE PREPARATION

Dewatering Rate 30 gpm

Capital Items	Quantity	Units	Cost
Excavation and On-Site Treatment			
Mobilization	1	LS	$100,000
Mobilization, Sediment Offloading Crane	1	LS	$50,000
Dewatering Treatment System, Purchase	1	LS	100,000
On-Site Thermal Treatment, Mobilization	1	LS	100,000
Direct Capital:			$350,000
Engineering, Procurement & Construction Management:			42,000
Contingency:			52,500
Total Capital:			$444,500
Total Project Capital and O & M Cost:			**$444,500**

COST ESTIMATE FOR DEMOLITION

Capital Items	Quantity	Units	Cost
In-Water Pilings/Dolphins			
Mobilization	1	LS	$60,000
Removal/Offloading	26	EA	$26,000
Disposal	26	EA	$13,000
Demolition			
Upland/Nearshore Structures	1	LS	50,000
Direct Capital:			$149,000
Engineering, Procurement & Construction Management:			17,880
Contingency:			22,350
Total Capital:			$189,230
Total Project Capital and O & M Cost:			**$189,230**

COST ESTIMATE FOR HAZARDOUS WASTE EXCAVATION AND INCINERATION

Capital Items	Quantity	Units	Cost
Excavation and Incineration			
Excavation	500	cy	$5,000
Backfilling w/On-Site Soil	500	cy	3,500
Incineration	700	ton	525,000
Excavation Confirmation	1	LS	20,000
Direct Capital:			$553,500
Engineering, Procurement & Construction Management:			66,420
Contingency:			83,025
Total Capital:			$702,945
Total Project Capital and O & M Cost:			**$702,945**

COST ESTIMATE FOR
BAXTER NEARSHORE SOIL TREATMENT

Dewatering Rate 26 gpm

Capital Items	Quantity	Units	Cost
Excavation and On-Site Treatment			
Soil Excavation	13,620	cy	$136,200
Backfilling w/on-site Soil	13,620	cy	95,340
Dewatering Treatment	1,019,866	gal	10,199
Temporary Steel Piling	10,500	sf	157,500
On-Site Thermal Treatment	19,068	ton	762,720
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000
Direct Capital:			$1,191,959
Engineering, Procurement & Construction Management:			143,035
Contingency:			178,794
Total Capital:			$1,513,787
Total Project Capital and O & M Cost:			**$1,513,787**

COST ESTIMATE FOR
BAXTER FARSHORE SOIL TREATMENT

Capital Items	Quantity	Units	Cost
Excavation and On-Site Treatment			
Soil Excavation	4,800	cy	$48,000
Backfilling w/on-site Soil	4,800	cy	33,600
On-Site Thermal Treatment	6,720	ton	268,800
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000
Direct Capital:			$380,400
Engineering, Procurement & Construction Management:			45,648
Contingency:			57,060
Total Capital:			$483,108
Total Project Capital and O & M Cost:			**$483,108**

COST ESTIMATE FOR DRIP TRACK SOIL TREATMENT

Capital Items	Quantity	Units	Cost
Excavation and On-Site Treatment			
Soil Excavation	2,000	cy	$20,000
Backfilling w/on-site Soil	2,000	cy	14,000
On-Site Thermal Treatment	2,800	ton	112,000
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000
Direct Capital:			$176,000
Engineering, Procurement & Construction Management:			21,120
Contingency:			26,400
Total Capital:			$223,520
Total Project Capital and O & M Cost:			$223,520

COST ESTIMATE FOR BARKER SOIL TREATMENT

Capital Items	Quantity	Units	Cost
Excavation and On-Site Treatment			
Soil Excavation	500	cy	$5,000
Backfilling w/on-site Soil	500	cy	3,500
On-Site Thermal Treatment	700	ton	28,000
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000
Direct Capital:			$66,500
Engineering, Procurement & Construction Management:			7,980
Contingency:			9,975
Total Capital:			$84,455
Total Project Capital and O & M Cost:			$84,455

COST ESTIMATE FOR SITE CAPPING

BAXTER NEARSHORE

Capital Items	Quantity	Units	Cost
Cap with Liner and Fill	33,060	sf	$66,120
Upland Offloading of Cedar River Sediment	3,673	cy	$12,857
Capping QA/QC	1	LS	10,000

Direct Capital:	$88,977
Engineering, Procurement & Construction Management:	10,677
Contingency:	13,347
Total Capital:	$113,000

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of Cap	30	890	10,017

Total Present Worth, Longer Term O & M Costs:	$10,017
Total Project Capital and O & M Cost:	**$123,017**

BAXTER FARSHORE

Capital Items	Quantity	Units	Cost
Cap with Liner and Fill	26,230	sf	$52,460
Upland Offloading of Cedar River Sediment	2,914	cy	$10,201
Capping QA/QC	1	LS	10,000

Direct Capital:	$72,661
Engineering, Procurement & Construction Management:	8,719
Contingency:	10,899
Total Capital:	$92,279

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of Cap	30	727	8,180

Total Present Worth, Longer Term O & M Costs:	$8,180
Total Project Capital and O & M Cost:	**$100,459**

REMAINDER OF METHOD B EXCEEDANCE AREAS

Capital Items	Quantity	Units	Cost
Cap with 3 feet of Clean Fill	335,178	sf	$335,178
Upland Offloading of Cedar River Sediment	37,242	cy	$130,347
Capping QA/QC	1	LS	10,000

Direct Capital:	$475,524
Engineering, Procurement & Construction Management:	57,063
Contingency:	71,329
Total Capital:	$603,916

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of Cap	30	4,755	53,533

Total Present Worth, Longer Term O & M Costs:	$53,533
Total Project Capital and O & M Cost:	**$657,449**

COST ESTIMATE FOR
BAXTER COVE EXCAVATION & TREATMENT

Capital Items	Quantity	Units	Cost
Excavation			
Construct Berm/Dewater	1	LS	10,000
Excavation	900	cy	9,000
Backfilling	900	cy	7,200
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000
Dewatering			
Water Treatment	75,519	gal	755
Soil Treatment			
Upland Handling	900	cy	4,500
On-Site Thermal	1,260	ton	50,400
Direct Capital:			$111,855
Engineering, Procurement & Construction Management:			13,423
Contingency:			16,778
Total Capital:			$142,056
Total Project Capital and O & M Cost:			**$142,056**

COST ESTIMATE FOR
MITIGATION - GYPSY CREEK REALIGNMENT

Capital Items	Quantity	Units	Cost
Gypsy Creek Realignment	1	LS	400,000
Direct Capital:			$400,000
Engineering, Procurement & Construction Management:			48,000
Contingency:			60,000
Total Capital:			$508,000
Total Project Capital and O & M Cost:			**$508,000**

COST ESTIMATE FOR GROUNDWATER EXTRACTION & TREATMENT

Capital Items	Quantity	Units		Cost
Upgrade Dewatering Treatment System	1	LS		$100,000
<u>Groundwater Extraction</u>				
Mobilization	1	LS		$10,000
Extraction Wells	4	ea		$100,000
Direct Capital:				$210,000
Engineering, Procurement & Construction Management:				25,200
Contingency:				31,500
Total Capital:				$266,700
Present Worth of Longer Term Operating Costs		**Years**	**Annual Cost**	**Cost**
Water Treatment		10	131,400	881,705
Total Present Worth, Longer Term O & M Costs:				$881,705
Total Project Capital and O & M Cost:				**$1,148,405**

COST ESTIMATE FOR INSTITUTIONAL CONTROLS AND MONITORING

Capital Items	Quantity	Units		Cost
Institutional Controls				
Public Education Program	1	LS		$20,000
Maintaining O&M Plans	1	LS		$8,000
Deed Restrictions	1	LS		$5,000
Groundwater Monitoring				
Wells	4	ea		$40,000
Plans	1	LS		$20,000
Direct Capital:				$93,000
Engineering, Procurement & Construction Management:				11,160
Contingency:				13,950
Total Capital:				$118,110
Present Worth of Longer Term Operating Costs		**Years**	**Annual Cost**	**Cost**
Public Education Program		30	1,000	11,258
Maintaining O&M Plans		30	800	9,006
Sampling and Analytical		30	25,000	281,445
Reporting		30	10,000	112,578
Total Present Worth, Longer Term O & M Costs:				$414,286
Total Project Capital and O & M Cost:				$532,396

PROBABLE UPPER SITE REMEDIATION COST ESTIMATE
BAXTER AND NORTH BAXTER PROPERTIES
PORT QUENDALL DEVELOPMENT

Material Handling Assumptions:	**Excavation**		**Surface Area**			
Hazardous Waste (Baxter Lagoon)	**850**	cy	2,180 sf			
Baxter Nearshore	**23,154**	cy	33,060 sf			
Baxter Farshore	**8,160**	cy	26,230 sf			
Drip Tracks	**3,400**	cy				
Barker	**850**	cy				
Baxter Cove	**1,530**	cy				
Capping Area Assumptions:						
Total Area Exceeding Method B	700,000	sf				
Area to be Capped with Liner and Fill	59,290	sf				
Area Covered by Development Features	50%					
Area to be Capped with 3 feet of Clean Fill	335,178	sf				
Cost Estimating Parameters & Methodology:						
Interest Rate	8.0%					
Soil Density (in situ)	1.40	tons/cy				
Excavation and Backfilling						
Mobilization	$100,000					
Excavation/Stockpiling	$10	per cy				
Excavation/Backfill Rate	1,000	cy per day				
Dewatering System Install	**$150,000**	ls				
Water Treatment	**$0.02**	per gallon				
Temporary Steel Piling	$15	per sf				
Backfill and Compact On-Site Soil	$7	per cy				
Upland Handling	$5	per cy				
Baxter Cove Excavation						
Initial Moisture Content (% mass)	55%					
Moisture Content After Dewatering	30%					
Excavation	$10					
Backfill	$8					
Capping						
Clean Fill Capping	$1.00	per sf			1.0%	of capital cost
Liner and Fill Capping	$2.00	per sf			1.0%	of capital cost
Offloading Crane Mobilization	$50,000					
Clean Sediment Offloading Rate	1,000	cy per shift				
Clean Sediment Offload Shift Rate	$3,500	per shift				
Soil Treatment						
On-Site Thermal Treatment	$100,000	mobilization, plus				
	$50	per ton				
Off-Site Incineration	**$1,000**	per ton				
Analytical Costs per Excavation Area						
Excavation Confirmation	$20,000	LS	Soil Treatment QA	$20,000	LS	
Groundwater Extraction						
Upgrade Dewatering System	**$200,000**					
Extraction Wells, Piping, etc. (6" PVC x 40 feet)	$25,000	each				
Number of Extraction Wells	**8**					
Extraction Rate	50	gpm				
Groundwater Treatment	$15	per 1000 gal				
Groundwater Monitoring						
Monitoring Wells	$10,000	ea				
Number of Monitoring Wells	**10**					
Plans	$20,000					
Sampling and Analytical	**$50,000**	per year				
Reporting	**$20,000**	per year				
In ional Controls						
Public Education Program	$20,000	originally, plus			$1,000	per year
Maintaining O&M Plans	$8,000	originally, plus			$800	per year
Deed Restrictions	$5,000	originally				
Engineering, Procurement & Construction Management	12%	of capital				
Contingency	15%	of capital				

COST ESTIMATE FOR MOBILIZATION/SITE PREPARATION

Dewatering Rate 30 gpm

Capital Items	Quantity	Units	Cost
Excavation and On-Site Treatment			
Mobilization	1	LS	$100,000
Mobilization, Sediment Offloading Crane	1	LS	$50,000
Dewatering Treatment System, Purchase	1	LS	150,000
On-Site Thermal Treatment, Mobilization	1	LS	100,000
Direct Capital:			$400,000
Engineering, Procurement & Construction Management:			48,000
Contingency:			60,000
Total Capital:			$508,000
Total Project Capital and O & M Cost:			**$508,000**

COST ESTIMATE FOR DEMOLITION

Capital Items	Quantity	Units	Cost
In-Water Pilings/Dolphins			
Mobilization	1	LS	$60,000
Removal/Offloading	26	EA	$26,000
Disposal	26	EA	$13,000
Demolition			
Upland/Nearshore Structures	1	LS	50,000
Direct Capital:			$149,000
Engineering, Procurement & Construction Management:			17,880
Contingency:			22,350
Total Capital:			$189,230
Total Project Capital and O & M Cost:			**$189,230**

COST ESTIMATE FOR HAZARDOUS WASTE EXCAVATION AND INCINERATION

Capital Items	Quantity	Units	Cost
Excavation and Incineration			
Excavation	850	cy	$8,500
Backfilling w/On-Site Soil	850	cy	5,950
Incineration	1,190	ton	1,190,000
Excavation Confirmation	1	LS	20,000
Direct Capital:			$1,224,450
Engineering, Procurement & Construction Management:			146,934
Contingency:			183,668
Total Capital:			$1,555,052
Total Project Capital and O & M Cost:			**$1,555,052**

COST ESTIMATE FOR BAXTER NEARSHORE SOIL TREATMENT

Dewatering Rate 26 gpm

Capital Items	Quantity	Units	Cost
<u>Excavation and On-Site Treatment</u>			
Soil Excavation	23,154	cy	$231,540
Backfilling w/on-site Soil	23,154	cy	162,078
Dewatering Treatment	1,733,772	gal	34,675
Temporary Steel Piling	10,500	sf	157,500
On-Site Thermal Treatment	32,416	ton	1,620,780
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	20,000
Direct Capital:			$2,246,573
Engineering, Procurement & Construction Management:			269,589
Contingency:			336,986
Total Capital:			$2,853,148
Total Project Capital and O & M Cost:			**$2,853,148**

COST ESTIMATE FOR BAXTER FARSHORE SOIL TREATMENT

Capital Items	Quantity	Units	Cost
<u>xcavation and On-Site Treatment</u>			
Soil Excavation	8,160	cy	$81,600
Backfilling w/on-site Soil	8,160	cy	57,120
On-Site Thermal Treatment	11,424	ton	571,200
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	20,000
Direct Capital:			$749,920
Engineering, Procurement & Construction Management:			89,990
Contingency:			112,488
Total Capital:			$952,398
Total Project Capital and O & M Cost:			**$952,398**

COST ESTIMATE FOR DRIP TRACK SOIL TREATMENT

Capital Items	Quantity	Units	Cost
Excavation and On-Site Treatment			
Soil Excavation	3,400	cy	$34,000
Backfilling w/on-site Soil	3,400	cy	23,800
On-Site Thermal Treatment	4,760	ton	238,000
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	20,000
Direct Capital:			$335,800
Engineering, Procurement & Construction Management:			40,296
Contingency:			50,370
Total Capital:			$426,466
Total Project Capital and O & M Cost:			**$426,466**

COST ESTIMATE FOR BARKER SOIL TREATMENT

Capital Items	Quantity	Units	Cost
Excavation and On-Site Treatment			
Soil Excavation	850	cy	$8,500
Backfilling w/on-site Soil	850	cy	5,950
On-Site Thermal Treatment	1,190	ton	59,500
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	20,000
Direct Capital:			$113,950
Engineering, Procurement & Construction Management:			13,674
Contingency:			17,093
Total Capital:			$144,717
Total Project Capital and O & M Cost:			**$144,717**

COST ESTIMATE FOR SITE CAPPING

BAXTER NEARSHORE

Capital Items	Quantity	Units		Cost
Cap with Liner and Fill	33,060	sf		$66,120
Upland Offloading of Cedar River Sediment	3,673	cy		$12,857
Capping QA/QC	1	LS		20,000
Direct Capital:				$98,977
Engineering, Procurement & Construction Management:				11,877
Contingency:				14,847
Total Capital:				$125,700
Present Worth of Longer Term Operating Costs	**Years**		**Annual Cost**	**Cost**
Maintenance of Cap	30		990	11,143
Total Present Worth, Longer Term O & M Costs:				$11,143
Total Project Capital and O & M Cost:				**$136,843**

BAXTER FARSHORE

Capital Items	Quantity	Units		Cost
Cap with Liner and Fill	26,230	sf		$52,460
Upland Offloading of Cedar River Sediment	2,914	cy		$10,201
Capping QA/QC	1	LS		20,000
Direct Capital:				$82,661
Engineering, Procurement & Construction Management:				9,919
Contingency:				12,399
Total Capital:				$104,979
Present Worth of Longer Term Operating Costs	**Years**		**Annual Cost**	**Cost**
Maintenance of Cap	30		827	9,306
Total Present Worth, Longer Term O & M Costs:				$9,306
Total Project Capital and O & M Cost:				**$114,285**

REMAINDER OF METHOD B EXCEEDANCE AREAS

Capital Items	Quantity	Units		Cost
Cap with 3 feet of Clean Fill	335,178	sf		$335,178
Upland Offloading of Cedar River Sediment	37,242	cy		$130,347
Capping QA/QC	1	LS		20,000
Direct Capital:				$485,524
Engineering, Procurement & Construction Management:				58,263
Contingency:				72,829
Total Capital:				$616,616
Present Worth of Longer Term Operating Costs	**Years**		**Annual Cost**	**Cost**
Maintenance of Cap	30		4,855	54,659
Total Present Worth, Longer Term O & M Costs:				$54,659
Total Project Capital and O & M Cost:				**$671,275**

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COST ESTIMATE FOR BAXTER COVE EXCAVATION & TREATMENT

Capital Items	Quantity	Units	Cost
Excavation			
Construct Berm/Dewater	1	LS	10,000
Excavation	1530	cy	15,300
Backfilling	1530	cy	12,240
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	20,000
Dewatering			
Water Treatment	128,383	gal	2,568
Soil Treatment			
Upland Handling	1,530	cy	7,650
On-Site Thermal	2,142	ton	107,100
Direct Capital:			$194,858
Engineering, Procurement & Construction Management:			23,383
Contingency:			29,229
Total Capital:			$247,469
Total Project Capital and O & M Cost:			**$247,469**

COST ESTIMATE FOR MITIGATION - GYPSY CREEK REALIGNMENT

Capital Items	Quantity	Units	Cost
Gypsy Creek Realignment	1	LS	400,000
Direct Capital:			$400,000
Engineering, Procurement & Construction Management:			48,000
Contingency:			60,000
Total Capital:			$508,000
Total Project Capital and O & M Cost:			**$508,000**

COST ESTIMATE FOR GROUNDWATER EXTRACTION & TREATMENT

Capital Items	Quantity	Units		Cost
Upgrade Dewatering Treatment System	1	LS		$200,000
<u>Groundwater Extraction</u>				
Mobilization	1	LS		$10,000
Extraction Wells	8	ea		$200,000
	Direct Capital:			$410,000
	Engineering, Procurement & Construction Management:			49,200
	Contingency:			61,500
	Total Capital:			$520,700

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Water Treatment	10	394,200	2,645,114
Total Present Worth, Longer Term O & M Costs:			$2,645,114
Total Project Capital and O & M Cost:			**$3,165,814**

COST ESTIMATE FOR: INSTITUTIONAL CONTROLS AND MONITORING

Capital Items	Quantity	Units		Cost
Institutional Controls				
Public Education Program	1	LS		$20,000
Maintaining O&M Plans	1	LS		$8,000
Deed Restrictions	1	LS		$5,000
Groundwater Monitoring				
Wells	10	ea		$100,000
Plans	1	LS		$20,000
Direct Capital:				$153,000
Engineering, Procurement & Construction Management:				18,360
Contingency:				22,950
Total Capital:				$194,310
Present Worth of Longer Term Operating Costs		**Years**	**Annual Cost**	**Cost**
Public Education Program		30	1,000	11,258
Maintaining O&M Plans		30	800	9,006
Sampling and Analytical		30	50,000	562,889
Reporting		30	20,000	225,156
Total Present Worth, Longer Term O & M Costs:				$808,309
Total Project Capital and O & M Cost:				**$1,002,619**

FEASIBILITY STUDY COST ESTIMATES
A - SOIL REMEDIATION (QUENDALL PROBABLE LEAST)
PORT QUENDALL DEVELOPMENT

Material Handling Assumptions:	**Overburden**	**Impacted Volume**	**Surface Area**
Quendall Pond	**6,910 cy**	**14,900 cy**	34,300 sf
Former May Creek	**15,210 cy**	**8,210 cy**	38,780 sf
North Sump	**13,740 cy**	**5,930 cy**	32,260 sf
Still House	**22,690 cy**	**20,010 cy**	115,190 sf
			220,530 sf

Capping Area Assumptions:		
Total Area Exceeding Method B	877,060 sf	
Area to be Capped with Liner and Fill	220,530 sf	
Area Covered by Development Features	438,530 sf	
Area to be Capped with 3 feet of Clean Fill	218,000 sf	
Cost Estimating Parameters & Methodology:		
Interest Rate	8.0%	
Soil Density (in situ)	1.40 tons/cy	
Excavation and Backfilling		
Mobilization	**$50,000**	
Excavation/Stockpiling	$8.00 per cy	
Excavation/Backfill Rate	1,000 cy per day	
Dewatering System Install	$10,000 per well	
Dewatering Treatment	$200,000 x (gpm/50)^0.5	**$0.003** per gallon carbon rege
Dewatering Discharge to METRO	**$0.006** per gal	
Temporary Steel Piling	$15 per sf	
Backfill and Compact On-Site Soil	$5.00 per cy	
Capping		
Mobilization	$50,000	
Asphalt Capping	$1.00 per sf	2.0% of capital cost
Clean Fill Capping	$1.00 per sf	1.0% of capital cost
Liner and Fill Capping	$2.00 per sf	1.0% of capital cost
DNAPL Recovery - Bioslurry Trenching		
Mobilization	$50,000 LS	
Trenching, Backfill	$40 per sf	
Sumps, Pumps, Piping, Controls, Installed	$20,000 each	10.0% of capital cost
Soil Treatment		
On-Site Thermal Treatment	$100,000 mobilization, plus	**$40** per ton
Off-Site Incineration	$750 per ton	
In Situ Stabilization	$150,000 per rig Mobilization	$60 per cy
	$30,000 treatability	
InSitu Stabilization Rate	400 cy per rig per shift	
Institutional Controls		
Public Education Program	$20,000 originally, plus	$1,000 per year
Maintaining O&M Plans	$8,000 originally, plus	$800 per year
Deed Restrictions	$5,000 originally	
Analytical Costs per Excavation Area		
Excavation Confirmation	$20,000 LS	
Soil Treatment QA/Cap QA	$10,000 LS	
Engineering, Procurement & Construction Management	12% of capital	
Contingency	15% of capital	

COST ESTIMATE FOR
SOIL TREATMENT - MOBILIZATION/SITE PREPARATION

EXCAVATION AND ON-SITE THERMAL Dewatering Rate 50 gpm

Capital Items	**Quantity**	**Units**	**Cost**
Excavation and On-Site Treatment			
Mobilization	1	LS	$50,000
Dewatering Treatment System, Purchase	1	LS	200,000
On-Site Thermal Treatment, Mobilization	1	LS	100,000
Institutional Controls			
Public Education Program	1	LS	20,000
Maintaining O&M Plans	1	LS	8,000
Deed Restrictions	1	LS	5,000
Direct Capital:			$383,000
Engineering, Procurement & Construction Management:			45,960
Contingency:			57,450
Total Capital:			$486,410

Present Worth of Longer Term Operating Costs	**Years**	**Annual Cost**	**Cost**
Institutional Controls			
Public Education Program	30	1000	11,258
Maintaining O&M Plans	30	800	9,006
Total Present Worth, Longer Term O & M Costs:			$20,264
Total Project Capital and O & M Cost:			**$506,674**

COST ESTIMATE FOR
QUENDALL POND SOIL TREATMENT

EXCAVATION AND ON-SITE THERMAL Dewatering Rate **24** gpm

Capital Items	**Quantity**	**Units**	**Cost**
Excavation and On-Site Treatment			
Soil Excavation	21,810	cy	$174,480
Backfilling w/on-site Soil	21,810	cy	109,050
Dewatering System Install	8	well	80,000
Dewatering Treatment - Carbon Regen	1,507,507	gal	4,523
Dewatering Discharge	1,507,507	gal	9,045
Temporary Steel Piling	15,000	sf	225,000
On-Site Thermal Treatment	20,860	ton	834,400
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000

Direct Capital:	$1,466,498
Engineering, Procurement & Construction Management:	175,980
Contingency:	219,975
Total Capital:	$1,862,452
Total Project Capital and O & M Cost:	**$1,862,452**

COST ESTIMATE FOR
FORMER MAY CREEK SOIL TREATMENT

EXCAVATION AND ON-SITE THERMAL Dewatering Rate **32** gpm

Capital Items	Quantity	Units	Cost
Excavation and On-Site Treatment			
Soil Excavation	23,420	cy	$187,360
Backfilling w/on-site Soil	23,420	cy	117,100
Dewatering System Install	8	well	80,000
Dewatering Treatment - Carbon Regen	2,158,387	gal	6,475
Dewatering Discharge	2,158,387	gal	12,950
Temporary Steel Piling	9,000	sf	135,000
On-Site Thermal Treatment	11,494	ton	459,760
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000
Direct Capital:			$1,028,645
Engineering, Procurement & Construction Management:			123,437
Contingency:			154,297
Total Capital:			$1,306,380
Total Project Capital and O & M Cost:			**$1,306,380**

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COST ESTIMATE FOR
NORTH SUMP SOIL TREATMENT

EXCAVATION AND ON-SITE THERMAL Dewatering Rate **34** gpm

Capital Items	**Quantity**	**Units**	**Cost**
Excavation and On-Site Treatment			
Soil Excavation	19,670	cy	$157,360
Backfilling w/on-site Soil	19,670	cy	98,350
Dewatering System Install	8	well	80,000
Dewatering Treatment - Carbon Regen	1,926,086	gal	5,778
Dewatering Discharge	1,926,086	gal	11,557
On-Site Thermal Treatment	8,302	ton	332,080
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000

Direct Capital:	$715,125
Engineering, Procurement & Construction Management:	85,815
Contingency:	107,269
Total Capital:	$908,208
Total Project Capital and O & M Cost:	**$908,208**

COST ESTIMATE FOR
STILL HOUSE SOIL TREATMENT

EXCAVATION AND ON-SITE THERMAL Dewatering Rate **25** gpm

Capital Items	**Quantity**	**Units**	**Cost**
<u>Excavation and On-Site Treatment</u>			
Soil Excavation	42,700	cy	$341,600
Backfilling w/on-site Soil	42,700	cy	213,500
Dewatering System Install	8	well	80,000
Dewatering Treatment - Carbon Regen	3,074,400	gal	9,223
Dewatering Discharge	3,074,400	gal	18,446
On-Site Thermal Treatment	28,014	ton	1,120,560
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000

Direct Capital:	$1,813,330
Engineering, Procurement & Construction Management:	217,600
Contingency:	271,999
Total Capital:	$2,302,929
Total Project Capital and O & M Cost:	**$2,302,929**

COST ESTIMATE FOR
SITE CAPPING

MOBILIZATION/SITE PREPARATION

Capital Items	Quantity	Units	Cost
Mobilization	1	LS	$50,000

Direct Capital:	$50,000
Engineering, Procurement & Construction Management:	6,000
Contingency:	7,500
Total Capital:	$63,500
Total Project Capital and O & M Cost:	**$63,500**

QUENDALL POND

Capital Items	Quantity	Units	Cost
Cap with Liner and Fill	34,300	sf	$68,600
Upland Offloading of Cedar River Sediment	3,811	cy	$8,341
Capping QA/QC	1	LS	10,000

Direct Capital:	$86,941
Engineering, Procurement & Construction Management:	10,433
Contingency:	13,041
Total Capital:	$110,415

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of Cap	30	869	9,788

Total Present Worth, Longer Term O & M Costs:	$9,788
Total Project Capital and O & M Cost:	**$120,203**

FORMER MAY CREEK

Capital Items	Quantity	Units	Cost
Cap with Liner and Fill	38,780	sf	$77,560
Upland Offloading of Cedar River Sediment	4,309	cy	$9,431
Capping QA/QC	1	LS	10,000

Direct Capital:	$96,991
Engineering, Procurement & Construction Management:	11,639
Contingency:	14,549
Total Capital:	$123,178

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of Cap	30	970	10,919

Total Present Worth, Longer Term O & M Costs:	$10,919
Total Project Capital and O & M Cost:	**$134,097**

COST ESTIMATE FOR SITE CAPPING

NORTH SUMP

Capital Items	Quantity	Units		Cost
Cap with Liner and Fill	32,260	sf		$64,520
Upland Offloading of Cedar River Sediment	3,584	cy		$7,845
Capping QA/QC	1	LS		10,000
Direct Capital:				$82,365
Engineering, Procurement & Construction Management:				9,884
Contingency:				12,355
Total Capital:				$104,604
Present Worth of Longer Term Operating Costs		**Years**	**Annual Cost**	**Cost**
Maintenance of Cap		30	824	9,272
Total Present Worth, Longer Term O & M Costs:				$9,272
Total Project Capital and O & M Cost:				**$113,876**

STILL HOUSE

Capital Items	Quantity	Units		Cost
Cap with Liner and Fill	115,190	sf		$230,380
Upland Offloading of Cedar River Sediment	12,799	cy		$28,013
Capping QA/QC	1	LS		10,000
Direct Capital:				$268,393
Engineering, Procurement & Construction Management:				32,207
Contingency:				40,259
Total Capital:				$340,859
Present Worth of Longer Term Operating Costs		**Years**	**Annual Cost**	**Cost**
Maintenance of Cap		30	2,684	30,215
Total Present Worth, Longer Term O & M Costs:				$30,215
Total Project Capital and O & M Cost:				**$371,074**

COST ESTIMATE FOR
SITE CAPPING

REMAINDER OF METHOD B EXCEEDANCE AREAS

Capital Items	**Quantity**	**Units**		**Cost**
Cap with 3 feet of Clean Fill	218,000	sf		$218,000
Upland Offloading of Cedar River Sediment	24,222	cy		$53,015
Capping QA/QC	1	LS		10,000
Direct Capital:				$281,015
Engineering, Procurement & Construction Management:				33,722
Contingency:				42,152
Total Capital:				$356,889
Present Worth of Longer Term Operating Costs		**Years**	**Annual Cost**	**Cost**
Maintenance of Cap		30	2,810	31,636
Total Present Worth, Longer Term O & M Costs:				$31,636
Total Project Capital and O & M Cost:				**$388,525**

COST ESTIMATE FOR DNAPL RECOVERY

MOBILIZATION/SITE PREPARATION

Capital Items		Quantity	Units	Cost
Mobilization		1	LS	$50,000
	Direct Capital:			$50,000
	Engineering, Procurement & Construction Management:			6,000
	Contingency:			7,500
	Total Capital:			$63,500
	Total Project Capital and O & M Cost:			**$63,500**

QUENDALL POND

Capital Items		Quantity	Units		Cost
Trench Construction		7,500	sf		$300,000
Soil Treatment		1,167	ton		$46,667
Sumps, Pumps, etc.		1	ea		20,000
	Direct Capital:				$366,667
	Engineering, Procurement & Construction Management:				44,000
	Contingency:				55,000
	Total Capital:				$465,667
Present Worth of Longer Term Operating Costs			**Years**	**Annual Cost**	**Cost**
Maintenance of System			30	36,667	412,785
	Total Present Worth, Longer Term O & M Costs:				$412,785
	Total Project Capital and O & M Cost:				**$878,452**

COST ESTIMATE FOR
DNAPL RECOVERY

FORMER MAY CREEK

Capital Items	Quantity	Units	Cost
Trench Construction	3,750	sf	$150,000
Soil Treatment	583	ton	$23,333
Sumps, Pumps, etc.	1	ea	20,000

Direct Capital:	$193,333
Engineering, Procurement & Construction Management:	23,200
Contingency:	29,000
Total Capital:	$245,533

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of System	30	19,333	217,650

Total Present Worth, Longer Term O & M Costs:	$217,650
Total Project Capital and O & M Cost:	**$463,184**

NORTH SUMP

Capital Items	Quantity	Units	Cost
Trench Construction	3,750	sf	$150,000
Soil Treatment	583	ton	$23,333
Sumps, Pumps, etc.	1	ea	20,000

Direct Capital:	$193,333
Engineering, Procurement & Construction Management:	23,200
Contingency:	29,000
Total Capital:	$245,533

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of System	30	19,333	217,650

Total Present Worth, Longer Term O & M Costs:	$217,650
Total Project Capital and O & M Cost:	**$463,184**

COST SUMMARY
A - SOIL REMEDIATION
PORT QUENDALL DEVELOPMENT

SOIL TREATMENT	
Mobilization/Site Prep	$506,674
Quendall Pond	$1,862,452
Former May Creek Channel	$1,306,380
North Sump	$908,208
Still House	$2,302,929
	$6,886,643
CAPPING	
Mobilization/Site Prep	$63,500
Quendall Pond	$120,203
Former May Creek Channel	$134,097
North Sump	$113,876
Still House	$371,074
Remainder of Method B Exceedance Areas	$388,525
	$1,191,275
DNAPL RECOVERY	
Mobilization/Site Prep	$63,500
Quendall Pond	$878,452
Former May Creek Channel	$463,184
North Sump	$463,184
	$1,868,320

FEASIBILITY STUDY COST ESTIMATES
D - CONTAINMENT WALL
PORT QUENDALL DEVELOPMENT

UPLAND WALL

Capital Items	Quantity	Units	Cost
Mobilization	1	LS	$100,000
Slurry Wall Installation	42,000	sf	$504,000
QA/QC	1	LS	50,000
Spoils Management			
Upland Handling	4,667	CY	$23,333
Treatment	6,533	TON	326,667

Direct Capital:	$1,004,000
Engineering, Procurement & Construction Management:	100,400
Contingency:	150,600
Total Capital:	$1,255,000
Total Project Capital and O & M Cost:	**$1,255,000**

NEARSHORE WALL

Capital Items	Quantity	Units	Cost
Mobilization	1	LS	$100,000
Steel Pile Wall Installation	45,000	sf	$855,000
QA/QC	1	LS	50,000

Direct Capital:	$1,005,000
Engineering, Procurement & Construction Management:	100,500
Contingency:	150,750
Total Capital:	$1,256,250
Total Project Capital and O & M Cost:	**$1,256,250**

CDF OUTER WALL

Capital Items	Quantity	Units	Cost
Mobilization	1	LS	$100,000
Steel Pile Wall Installation	48,000	sf	$912,000
QA/QC	1	LS	50,000

Direct Capital:	$1,062,000
Engineering, Procurement & Construction Management:	106,200
Contingency:	159,300
Total Capital:	$1,327,500
Total Project Capital and O & M Cost:	**$1,327,500**

COST SUMMARY
C - GROUNDWATER/D - CONTAINMENT WALL
PORT QUENDALL DEVELOPMENT

GROUNDWATER	
Biosparging	$999,167
Groundwater Extraction	$3,331,404
Institutional Control & Monitoring	$974,559
CONTAINMENT WALL	
Upland Wall	$1,255,000
Nearshore Wall	$1,256,250
CDF Outer Wall	$1,327,500

FEASIBILITY STUDY COST ESTIMATES
A - SOIL REMEDIATION (QUENDALL PROBABLE UPPER)
PORT QUENDALL DEVELOPMENT

Material Handling Assumptions:	**Overburden**	**Impacted Volume**	**Surface Area**
Quendall Pond	**11,747 cy**	**25,330 cy**	34,300 sf
Former May Creek	**25,857 cy**	**13,957 cy**	38,780 sf
North Sump	**23,358 cy**	**10,081 cy**	32,260 sf
Still House	**38,573 cy**	**34,017 cy**	115,190 sf
			220,530 sf

Capping Area Assumptions:		
Total Area Exceeding Method B	1,000,000 sf	
Area to be Capped with Liner and Fill	220,530 sf	
Area Covered by Development Features	500,000 sf	
Area to be Capped with 3 feet of Clean Fill	279,470 sf	
Cost Estimating Parameters & Methodology:		
Interest Rate	8.0%	
Soil Density (in situ)	1.40 tons/cy	
Excavation and Backfilling		
Mobilization	**$100,000**	
Excavation/Stockpiling	$8.00 per cy	
Excavation/Backfill Rate	1,000 cy per day	
Dewatering System Install	$10,000 per well	
Dewatering Treatment	$200,000 x (gpm/50)^0.5	**$0.008** per gallon carbon rege
Dewatering Discharge to METRO	**$0.012** per gal	
Temporary Steel Piling	$15 per sf	
Backfill and Compact On-Site Soil	$5.00 per cy	
Capping		
Mobilization	$50,000	
Asphalt Capping	$1.00 per sf	2.0% of capital cost
Clean Fill Capping	$1.00 per sf	1.0% of capital cost
Liner and Fill Capping	$2.00 per sf	1.0% of capital cost
DNAPL Recovery - Bioslurry Trenching		
Mobilization	$50,000 LS	
Trenching, Backfill	$40 per sf	
Sumps, Pumps, Piping, Controls, Installed	$20,000 each	10.0% of capital cost
Soil Treatment		
On-Site Thermal Treatment	$100,000 mobilization, plus	$50 per ton
Off-Site Incineration	$750 per ton	
In Situ Stabilization	$150,000 per rig Mobilization	$60 per cy
	$30,000 treatability	
InSitu Stabilization Rate	400 cy per rig per shift	
Institutional Controls		
Public Education Program	$20,000 originally, plus	$1,000 per year
Maintaining O&M Plans	$8,000 originally, plus	$800 per year
Deed Restrictions	$5,000 originally	
Analytical Costs per Excavation Area		
Excavation Confirmation	$20,000 LS	
Soil Treatment QA/Cap QA	$10,000 LS	
Engineering, Procurement & Construction Management	12% of capital	
Contingency	15% of capital	

COST ESTIMATE FOR
SOIL TREATMENT - MOBILIZATION/SITE PREPARATION

EXCAVATION AND ON-SITE THERMAL Dewatering Rate 50 gpm

Capital Items	**Quantity**	**Units**	**Cost**
Excavation and On-Site Treatment			
Mobilization	1	LS	$100,000
Dewatering Treatment System, Purchase	1	LS	200,000
On-Site Thermal Treatment, Mobilization	1	LS	100,000
Institutional Controls			
Public Education Program	1	LS	20,000
Maintaining O&M Plans	1	LS	8,000
Deed Restrictions	1	LS	5,000

Direct Capital:	$433,000
Engineering, Procurement & Construction Management:	51,960
Contingency:	64,950
Total Capital:	$549,910

Present Worth of Longer Term Operating Costs	**Years**	**Annual Cost**	**Cost**
Institutional Controls			
Public Education Program	30	1000	11,258
Maintaining O&M Plans	30	800	9,006

Total Present Worth, Longer Term O & M Costs:	$20,264
Total Project Capital and O & M Cost:	**$570,174**

COST ESTIMATE FOR
QUENDALL POND SOIL TREATMENT

EXCAVATION AND ON-SITE THERMAL Dewatering Rate **48** gpm

Capital Items	Quantity	Units	Cost
Excavation and On-Site Treatment			
Soil Excavation	37,077	cy	$296,616
Backfilling w/on-site Soil	37,077	cy	185,385
Dewatering System Install	8	well	80,000
Dewatering Treatment - Carbon Regen	5,125,524	gal	41,004
Dewatering Discharge	5,125,524	gal	61,506
Temporary Steel Piling	15,000	sf	225,000
On-Site Thermal Treatment	35,462	ton	1,773,100
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000

Direct Capital:	$2,692,611
Engineering, Procurement & Construction Management:	323,113
Contingency:	403,892
Total Capital:	$3,419,617
Total Project Capital and O & M Cost:	**$3,419,617**

COST ESTIMATE FOR
FORMER MAY CREEK SOIL TREATMENT

EXCAVATION AND ON-SITE THERMAL Dewatering Rate **64** gpm

Capital Items	**Quantity**	**Units**	**Cost**
Excavation and On-Site Treatment			
Soil Excavation	39,814	cy	$318,512
Backfilling w/on-site Soil	39,814	cy	199,070
Dewatering System Install	8	well	80,000
Dewatering Treatment - Carbon Regen	7,338,516	gal	58,708
Dewatering Discharge	7,338,516	gal	88,062
Temporary Steel Piling	9,000	sf	135,000
On-Site Thermal Treatment	19,540	ton	976,990
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000

Direct Capital:	$1,886,342
Engineering, Procurement & Construction Management:	226,361
Contingency:	282,951
Total Capital:	$2,395,655
Total Project Capital and O & M Cost:	**$2,395,655**

COST ESTIMATE FOR
NORTH SUMP SOIL TREATMENT

EXCAVATION AND ON-SITE THERMAL Dewatering Rate **68** gpm

Capital Items	**Quantity**	**Units**	**Cost**
Excavation and On-Site Treatment			
Soil Excavation	33,439	cy	$267,512
Backfilling w/on-site Soil	33,439	cy	167,195
Dewatering System Install	8	well	80,000
Dewatering Treatment - Carbon Regen	6,548,694	gal	52,390
Dewatering Discharge	6,548,694	gal	78,584
On-Site Thermal Treatment	14,113	ton	705,670
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000
Direct Capital:			$1,381,351
Engineering, Procurement & Construction Management:			165,762
Contingency:			207,203
Total Capital:			$1,754,316
Total Project Capital and O & M Cost:			**$1,754,316**

COST ESTIMATE FOR
STILL HOUSE SOIL TREATMENT

EXCAVATION AND ON-SITE THERMAL Dewatering Rate **50** gpm

Capital Items	**Quantity**	**Units**	**Cost**
Excavation and On-Site Treatment			
Soil Excavation	72,590	cy	$580,720
Backfilling w/on-site Soil	72,590	cy	362,950
Dewatering System Install	8	well	80,000
Dewatering Treatment - Carbon Regen	10,452,960	gal	83,624
Dewatering Discharge	10,452,960	gal	125,436
On-Site Thermal Treatment	47,624	ton	2,381,190
Excavation Confirmation	1	LS	20,000
Soil Treatment QA	1	LS	10,000

Direct Capital:	$3,643,919
Engineering, Procurement & Construction Management:	437,270
Contingency:	546,588
Total Capital:	$4,627,777
Total Project Capital and O & M Cost:	$4,627,777

CP 001111

COST ESTIMATE FOR SITE CAPPING

MOBILIZATION/SITE PREPARATION

Capital Items	Quantity	Units	Cost
Mobilization	1	LS	$50,000
Direct Capital:			$50,000
Engineering, Procurement & Construction Management:			6,000
Contingency:			7,500
Total Capital:			$63,500
Total Project Capital and O & M Cost:			**$63,500**

QUENDALL POND

Capital Items	Quantity	Units	Cost
Cap with Liner and Fill	34,300	sf	$68,600
Upland Offloading of Cedar River Sediment	3,811	cy	$8,341
Capping QA/QC	1	LS	10,000
Direct Capital:			$86,941
Engineering, Procurement & Construction Management:			10,433
Contingency:			13,041
Total Capital:			$110,415

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of Cap	30	869	9,788
Total Present Worth, Longer Term O & M Costs:			$9,788
Total Project Capital and O & M Cost:			**$120,203**

FORMER MAY CREEK

Capital Items	Quantity	Units	Cost
Cap with Liner and Fill	38,780	sf	$77,560
Upland Offloading of Cedar River Sediment	4,309	cy	$9,431
Capping QA/QC	1	LS	10,000
Direct Capital:			$96,991
Engineering, Procurement & Construction Management:			11,639
Contingency:			14,549
Total Capital:			$123,178

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
faintenance of Cap	30	970	10,919
Total Present Worth, Longer Term O & M Costs:			$10,919
Total Project Capital and O & M Cost:			**$134,097**

CP 001112

COST ESTIMATE FOR SITE CAPPING

NORTH SUMP

Capital Items	Quantity	Units	Cost
Cap with Liner and Fill	32,260	sf	$64,520
Upland Offloading of Cedar River Sediment	3,584	cy	$7,845
Capping QA/QC	1	LS	10,000

Direct Capital:	$82,365
Engineering, Procurement & Construction Management:	9,884
Contingency:	12,355
Total Capital:	$104,604

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of Cap	30	824	9,272

Total Present Worth, Longer Term O & M Costs:	$9,272
Total Project Capital and O & M Cost:	**$113,876**

STILL HOUSE

Capital Items	Quantity	Units	Cost
Cap with Liner and Fill	115,190	sf	$230,380
Upland Offloading of Cedar River Sediment	12,799	cy	$28,013
Capping QA/QC	1	LS	10,000

Direct Capital:	$268,393
Engineering, Procurement & Construction Management:	32,207
Contingency:	40,259
Total Capital:	$340,859

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of Cap	30	2,684	30,215

Total Present Worth, Longer Term O & M Costs:	$30,215
Total Project Capital and O & M Cost:	**$371,074**

COST ESTIMATE FOR
SITE CAPPING

REMAINDER OF METHOD B EXCEEDANCE AREAS

Capital Items	Quantity	Units	Cost
Cap with 3 feet of Clean Fill	279,470	sf	$279,470
Upland Offloading of Cedar River Sediment	31,052	cy	$67,963
Capping QA/QC	1	LS	10,000
Direct Capital:			$357,433
Engineering, Procurement & Construction Management:			42,892
Contingency:			53,615
Total Capital:			$453,940

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of Cap	30	3,574	40,239
Total Present Worth, Longer Term O & M Costs:			$40,239
Total Project Capital and O & M Cost:			**$494,179**

COST ESTIMATE FOR DNAPL RECOVERY

MOBILIZATION/SITE PREPARATION

Capital Items	Quantity	Units	Cost
Mobilization	1	LS	$50,000

Direct Capital:	$50,000
Engineering, Procurement & Construction Management:	6,000
Contingency:	7,500
Total Capital:	$63,500
Total Project Capital and O & M Cost:	**$63,500**

QUENDALL POND

Capital Items	Quantity	Units	Cost
Trench Construction	7,500	sf	$300,000
Soil Treatment	1,167	ton	$58,333
Sumps, Pumps, etc.	1	ea	20,000

Direct Capital:	$378,333
Engineering, Procurement & Construction Management:	45,400
Contingency:	56,750
Total Capital:	$480,483

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Maintenance of System	30	37,833	425,919

Total Present Worth, Longer Term O & M Costs:	$425,919
Total Project Capital and O & M Cost:	**$906,403**

COST ESTIMATE FOR DNAPL RECOVERY

FORMER MAY CREEK

Capital Items	Quantity	Units		Cost
Trench Construction	3,750	sf		$150,000
Soil Treatment	583	ton		$29,167
Sumps, Pumps, etc.	1	ea		20,000
Direct Capital:				$199,167
Engineering, Procurement & Construction Management:				23,900
Contingency:				29,875
Total Capital:				$252,942
Present Worth of Longer Term Operating Costs		**Years**	**Annual Cost**	**Cost**
Maintenance of System		30	19,917	224,218
Total Present Worth, Longer Term O & M Costs:				$224,218
Total Project Capital and O & M Cost:				**$477,159**

NORTH SUMP

Capital Items	Quantity	Units		Cost
Trench Construction	3,750	sf		$150,000
Soil Treatment	583	ton		$29,167
Sumps, Pumps, etc.	1	ea		20,000
Direct Capital:				$199,167
Engineering, Procurement & Construction Management:				23,900
Contingency:				29,875
Total Capital:				$252,942
Present Worth of Longer Term Operating Costs		**Years**	**Annual Cost**	**Cost**
Maintenance of System		30	19,917	224,218
Total Present Worth, Longer Term O & M Costs:				$224,218
Total Project Capital and O & M Cost:				**$477,159**

COST SUMMARY
A - SOIL REMEDIATION
PORT QUENDALL DEVELOPMENT

	EXCAVATION & THERMAL
SOIL TREATMENT	
Mobilization/Site Prep	$570,174
Quendall Pond	$3,419,617
Former May Creek Channel	$2,395,655
North Sump	$1,754,316
Still House	$4,627,777
	**********
CAPPING	
Mobilization/Site Prep	$63,500
Quendall Pond	$120,203
Former May Creek Channel	$134,097
North Sump	$113,876
Still House	$371,074
Remainder of Method B Exceedance Areas	$494,179
	$1,296,930
DNAPL RECOVERY	
Mobilization/Site Prep	$63,500
Quendall Pond	$906,403
Former May Creek Channel	$477,159
North Sump	$477,159
	$1,924,221

FEASIBILITY STUDY COST ESTIMATES
B - SEDIMENT REMEDIATION (QUENDALL PROBABLE LEAST)
PORT QUENDALL DEVELOPMENT

Material Handling Assumptions:	**Dredge Volume**		**Fill Volume**	
T-Dock	**12,400**	cy	12,400	cy
Nearshore (2.9 acre CDF)	**4,840**	cy	4,840	cy
Nearshore (0.5 acre containment)	**16,640**	cy	16,640	cy
Nearshore (to 6 ft below mud line)	**19,540**	cy	19,540	cy
Wood Waste	**48,200**	cy	0	cy
Grey Zone	**104,300**	cy	0	cy
CDF Wall			25,000	cy
Nearshore Containment (0.5 acres)			20,000	cy
Enhanced Natural Recovery			26,100	cy
Sediment Density - After dewatering	1.40	tons/cy		
Wood Waste Density	1.00	tons/cy		
Grey Zone Density	1.20	tons/cy		
<u>Mechanical Dredging</u>				
Initial Moisture Content (% mass - PAH only)	55%	Woodwaste/Grey Zone	60%	
Moisture Content After Barge	50%			
Moisture Content After Dewatering	30%			
Cost Estimating Parameters & Methodology:				
Interest Rate	8.0%			
<u>Dredging - Mechanical</u>				
Mobilization - Equipment	$80,000	per dredge		
Mobilization - Silt Curtain	$35,000			
Mobilization - Watertight Barge	$110,000	ea		
Shift Rate (8 hours) - Dredging	$5,600	per shift		
Shift Rate (8 hours) - Offloading	$2,900	per shift		
Debris Sweep Wash System	$38,000			
Debris Sweep Area	5	acres		
Debris Sweep Rate	1	acres per shift		
Clean/Wood Waste Dredging & Offloading Rate	1,325	cy per shift		
Clean/Wood Waste Dredge/Offload Shift Rate	$8,000	per shift		
Contaminated Dredging Rate	250	cy per shift		
Contaminated Upland Offloading Rate	500	cy per shift		
In-Water Thin Layer Filling Rate	1,000	cy per shift		
In-Water Bulk Filling Rate	1,500	cy per shift		
Average Water Generation Rate	**26**	gpm		
<u>Upland Management</u>				
Mobilization/Site Prep	$50,000			
<u>Mechanical Dredge Dewatering Cell</u>				
Dewatering Cell Construction	$2	per sf		
Soil Holding Time	3	days		
Soil Stockpile Height	3	feet		
<u>Dewatering Treatment</u>	$200,000	x (gpm/50)^0.5	**$0.003**	per gal carbon regen
Water Discharge to METRO	**$0.006**	per gal		
Upland Handling	$5	per cy		
Excavation - Baxter Cove	$10	per cy		
Backfilling and Compaction	$7	per cy		
<u>Sediment Treatment</u>				
On-Site Thermal Treatment	$100,000	mobilization, plus	$40	per ton
Off-Site Thermal Treatment, incl. transport	$4,500	setup/profiling +	$45	per ton
On-Site Recycling of Wood Waste	$12.00	per cy		
<u>Natural Recovery Monitoring</u>	$38,000	per year	$21,000	sampling/analytical
			$7,000	QA/Reporting
			$10,000	SPI Camera
<u>Ai cal Costs</u>				
Dredge Monitoring	$20,000			
Sediment Treatment QA	$20,000			
<u>Engineering, Procurement & Construction Management</u>	12%	of capital		
<u>Contingency</u>	15%	of capital		
Contractor Overhead/Profit	15%	of capital		

COST ESTIMATE FOR MOBILIZATION/SITE PREPARATION

Capital Items	Quantity	Units	Cost
Upland Mobilization/Site Prep	1	LS	$50,000
Dewatering Cell Construction	54,000	sf	$108,000
Water Tighten Barges	3	ea	$330,000
Direct Capital:			$330,000
Engineering, Procurement & Construction Management:			39,600
Contingency:			49,500
Contractor Overhead/Profit:			49,500
Total Capital:			$468,600
Total Project Capital and O & M Cost:			**$468,600**

COST ESTIMATE FOR REMOVE/RECYCLE WOOD WASTE

Capital Items	Quantity	Units	Cost
Pre-Dredge Debris Sweep			
Mobilization	1	ea	$115,000
Water Tighten Barges	1	ea	$110,000
Debris Sweep Wash Area	1	ea	$38,000
Dredging	5	acres	$28,000
Offloading	1	LS	$14,000
Dredging			
Mobilization	1	ea	$115,000
Dredging/Offloading/Screening	48,200	cy	$291,019
Dredge Monitoring	1	LS	$20,000
Upland Management			
Upland Handling	48,200	cy	241,000
On-Site Recycling	48,200	cy	578,400
Direct Capital:			$1,550,419
Engineering, Procurement & Construction Management:			186,050
Contingency:			232,563
Contractor Overhead/Profit:			232,563
Total Capital:			$2,201,595
Total Project Capital and O & M Cost:			**$2,201,595**

COST ESTIMATE FOR GREY ZONE DREDGING

Capital Items	Quantity	Units	Cost
Dredging			
Mobilization	1	ea	$115,000
Dredging/Offloading/Screening	104,300	cy	$629,736
Dredge Monitoring	1	LS	$20,000
Upland Management			
Upland Handling	104,300	cy	521,500
On-Site Recycling	104,300	cy	1,251,600

Direct Capital:	$2,537,836
Engineering, Procurement & Construction Management:	304,540
Contingency:	380,675
Contractor Overhead/Profit:	380,675
Total Capital:	$3,603,727
	-
Total Project Capital and O & M Cost:	**$3,603,727**

COST ESTIMATE FOR GREY ZONE NATURAL RECOVERY

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Natural Recovery Monitoring	10	38,000	254,983

Total Present Worth, Longer Term O & M Costs:	$254,983
Total Project Capital and O & M Cost:	**$254,983**

COST ESTIMATE FOR GREY ZONE ENHANCED NATURAL RECOVERY

Capital Items	Quantity	Units	Cost
Sediment Placement	26,100	cy	146,160

Direct Capital:	$146,160
Engineering, Procurement & Construction Management:	17,539
Contingency:	21,924
Contractor Overhead/Profit:	21,924
Total Capital:	$207,547

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Natural Recovery Monitoring	10	38,000	254,983

Total Present Worth, Longer Term O & M Costs:	$254,983
Total Project Capital and O & M Cost:	**$462,530**

COST ESTIMATE FOR
CONSTRUCT CDF (2.9 acres), DREDGE & PLACE T-DOCK & NEARSHORE

Capital Items	Quantity	Units	Cost
CDF Construction			
Pre-Placement Blanket	2,500	cy	$7,250
Sediment Placement	25,000	cy	$48,333
Dredging			
Mobilization	1	ea	$115,000
Dredging	17,240	cy	$386,176
Place in CDF	17,240	cy	$49,996
Cap CDF	5,000	cy	14,500
Backfill Dredge Area	17,240	cy	$49,996
Dredge Monitoring	1	LS	$20,000
Dewatering			
Water Treatment	1,446,613	gal	4,340
Air Sparging System			
Mobilization	1	LS	$50,000
Air Sparging Wells	40	ea	$400,000
Air Injection Blower, Controls, etc.	1	LS	$68,922

Direct Capital:	$1,214,513
Engineering, Procurement & Construction Management:	145,742
Contingency:	182,177
Contractor Overhead/Profit:	182,177
Total Capital:	$1,724,609

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Operation and Maintenance	30	72,871	820,364

Total Present Worth, Longer Term O & M Costs:	$820,364
Total Project Capital and O & M Cost:	**$2,544,972**

COST ESTIMATE FOR
NEARSHORE CONTAINMENT (0.5 acres), DREDGE & TREAT NEARSHORE TOE

Capital Items	Quantity	Units	Cost
Pre-Placement Blanket	2,500	cy	$7,250
Clean Fill Placement	20,000	cy	$38,667
Dredging			
Mobilization	1	ea	$115,000
Dredging	16,640	cy	$372,736
Upland Offloading	16,640	cy	$96,512
Dredge Area Backfill	16,640	cy	$48,256
Dredge Monitoring	1	LS	$20,000
Dewatering			
Water Treatment	1,396,267	gal	4,189
Treatment			
Upland Handling	16,640	cy	$83,200
On-Site Thermal	23,296	ton	931,840

Direct Capital:	$1,717,649
Engineering, Procurement & Construction Management:	206,118
Contingency:	257,647
Contractor Overhead/Profit:	257,647
Total Capital:	$2,439,062
Total Project Capital and O & M Cost:	**$2,439,062**

COST ESTIMATE FOR
T-DOCK DREDGING & TREATMENT

Capital Items	Quantity	Units	Cost
Dredging			
Mobilization	1	ea	$115,000
Dredging	12,400	cy	$277,760
Upland Offloading	12,400	cy	$71,920
Dredge Area Backfilling	12,400	cy	$35,960
Dredge Monitoring	1	LS	$20,000
Dewatering			
Water Treatment	1,040,487	gal	3,121
Treatment			
Upland Handling	12,400	cy	$62,000
On-Site Thermal	17,360	ton	694,400

Direct Capital:	$1,280,161
Engineering, Procurement & Construction Management:	153,619
Contingency:	192,024
Contractor Overhead/Profit:	192,024
Total Capital:	$1,817,829
Total Project Capital and O & M Cost:	**$1,817,829**

COST ESTIMATE FOR
NEARSHORE DREDGING & TREATMENT (6 ft below mud line)

Capital Items	Quantity	Units	Cost
Dredging			
Mobilization	1	ea	$115,000
Dredging	19,540	cy	$437,696
Upland Offloading	19,540	cy	$113,332
Dredge Area Backfilling	19,540	cy	$56,666
Dredge Monitoring	1	LS	$20,000
Dewatering			
Water Treatment	1,639,606	gal	4,919
Treatment			
Upland Handling	19,540	cy	$97,700
On-Site Thermal	27,356	ton	1,094,240

Direct Capital:	$1,939,553
Engineering, Procurement & Construction Management:	232,746
Contingency:	290,933
Contractor Overhead/Profit:	290,933
Total Capital:	$2,754,165
Total Project Capital and O & M Cost:	**$2,754,165**

COST ESTIMATE FOR
MITIGATION - WETLAND REPLACEMENT

Capital Items	Quantity	Units	Cost
Wetland Replacement	1	LS	$400,000

Direct Capital:	$400,000
Engineering, Procurement & Construction Management:	48,000
Contingency:	60,000
Total Capital:	$508,000
Total Project Capital and O & M Cost:	**$508,000**

COST ESTIMATE FOR
MITIGATION - GYPSY CREEK REALIGNMENT

Capital Items	Quantity	Units	Cost
Gypsy Creek Realignment	1	LS	400,000

Direct Capital:	$400,000
Engineering, Procurement & Construction Management:	48,000
Contingency:	60,000
Total Capital:	$508,000
Total Project Capital and O & M Cost:	**$508,000**

COST ESTIMATE FOR
MITIGATION - FOR CDF (2.9 acres)

Capital Items	Quantity	Units	Cost
2.9 acre Mitigation	1	LS	$400,000

Direct Capital:	$400,000
Engineering, Procurement & Construction Management:	48,000
Contingency:	60,000
Total Capital:	$508,000
Total Project Capital and O & M Cost:	**$508,000**

COST ESTIMATE FOR
MITIGATION - FOR NEARSHORE CONTAINMENT CELL

Capital Items	Quantity	Units	Cost
0.5 acre Mitigation	1	LS	400,000

Direct Capital:	$400,000
Engineering, Procurement & Construction Management:	48,000
Contingency:	60,000
Total Capital:	$508,000
Total Project Capital and O & M Cost:	**$508,000**

COST SUMMARY
B - SEDIMENT REMEDIATION/MITIGATION
PORT QUENDALL DEVELOPMENT

SEDIMENT REMEDIATION	
Mobilization/Site Preparation	$468,600
Remove/Recycle Wood Waste	$2,201,595
Grey Zone Dredging	$3,603,727
Grey Zone Natural Recovery	$254,983
Grey Zone Enhanced Natural Recovery	$462,530
Construct CDF (2.9 acres), Dredge & Place T-Dock and Nearshore	$2,544,972
Nearshore Containment (0.5 acres), Dredge and Treat Nearshore Toe	$2,439,062
T-Dock Dredging & Treatment	$1,817,829
Nearshore Dredging & Treatment (6 ft below mud line)	$2,754,165
MITIGATION	
Wetland Replacement	$508,000
Gypsy Creek Realignment	$508,000
For CDF (2.9 acres)	$508,000
For Nearshore Containment Cell (0.5 acres)	$508,000

FEASIBILITY STUDY COST ESTIMATES
B - SEDIMENT REMEDIATION (QUENDALL PROBABLE UPPER)
PORT QUENDALL DEVELOPMENT

Material Handling Assumptions:	**Dredge Volume**		**Fill Volume**	
T-Dock	**21,080** cy		21,080 cy	
Nearshore (2.9 acre CDF)	**8,228** cy		8,228 cy	
Nearshore (0.5 acre containment)	**28,288** cy		28,288 cy	
Nearshore (to 6 ft below mud line)	**33,218** cy		33,218 cy	
Wood Waste	**81,940** cy		0 cy	
Grey Zone	**177,310** cy		0 cy	
CDF Wall			25,000 cy	
Nearshore Containment (0.5 acres)			20,000 cy	
Enhanced Natural Recovery			26,100 cy	
Sediment Density - After dewatering	1.40 tons/cy			
Wood Waste Density	1.00 tons/cy			
Grey Zone Density	1.20 tons/cy			
Mechanical Dredging				
Initial Moisture Content (% mass - PAH only)	55%	Woodwaste/Grey Zone	60%	-
Moisture Content After Barge	50%			
Moisture Content After Dewatering	30%			
Cost Estimating Parameters & Methodology:				
Interest Rate	8.0%			
Dredging - Mechanical				
Mobilization - Equipment	$80,000 per dredge			
Mobilization - Silt Curtain	$35,000			
Mobilization - Watertight Barge	$110,000 ea			
Shift Rate (8 hours) - Dredging	$5,600 per shift			
ʾhift Rate (8 hours) - Offloading	$2,900 per shift			
ɹebris Sweep Wash System	$38,000			
Debris Sweep Area	5 acres			
Debris Sweep Rate	1 acres per shift			
Clean/Wood Waste Dredging & Offloading Rate	1,325 cy per shift			
Clean/Wood Waste Dredge/Offload Shift Rate	$8,000 per shift			
Contaminated Dredging Rate	250 cy per shift			
Contaminated Upland Offloading Rate	500 cy per shift			
In-Water Thin Layer Filling Rate	1,000 cy per shift			
In-Water Bulk Filling Rate	1,500 cy per shift			
Average Water Generation Rate	53 gpm			
Upland Management				
Mobilization/Site Prep	$50,000			
Mechanical Dredge Dewatering Cell				
Dewatering Cell Construction	$2 per sf			
Soil Holding Time	3 days			
Soil Stockpile Height	3 feet			
Dewatering Treatment	$200,000 x (gpm/50)^0.5		**$0.008**	per gal carbon regen
Water Discharge to METRO	**$0.012** per gal			
Upland Handling	$5 per cy			
Excavation - Baxter Cove	$10 per cy			
Backfilling and Compaction	$7 per cy			
Sediment Treatment				
On-Site Thermal Treatment	$100,000 mobilization, plus		$50	per ton
Off-Site Thermal Treatment, incl. transport	$4,500 setup/profiling +		$45	per ton
On-Site Recycling of Wood Waste	$12.00 per cy			
Natural Recovery Monitoring	$38,000 per year		$21,000	sampling/analytical
			$7,000	QA/Reporting
			$10,000	SPI Camera
A. .cal Costs				
Dredge Monitoring	$20,000			
Sediment Treatment QA	$20,000			
Engineering, Procurement & Construction Management	12% of capital			
Contingency	15% of capital			
Contractor Overhead/Profit	15% of capital			

COST ESTIMATE FOR MOBILIZATION/SITE PREPARATION

Capital Items	Quantity	Units	Cost
Upland Mobilization/Site Prep	1	LS	$50,000
Dewatering Cell Construction	54,000	sf	$108,000
Water Tighten Barges	3	ea	$330,000

Direct Capital:	$330,000
Engineering, Procurement & Construction Management:	39,600
Contingency:	49,500
Contractor Overhead/Profit:	49,500
Total Capital:	$468,600
Total Project Capital and O & M Cost:	**$468,600**

COST ESTIMATE FOR REMOVE/RECYCLE WOOD WASTE

Capital Items	Quantity	Units	Cost
Pre-Dredge Debris Sweep			
Mobilization	1	ea	$115,000
Water Tighten Barges	1	ea	$110,000
Debris Sweep Wash Area	1	ea	$38,000
Dredging	5	acres	$28,000
Offloading	1	LS	$14,000
Dredging			
Mobilization	1	ea	$115,000
Dredging/Offloading/Screening	81,940	cy	$494,732
Dredge Monitoring	1	LS	$20,000
Upland Management			
Upland Handling	81,940	cy	409,700
On-Site Recycling	81,940	cy	983,280

Direct Capital:	$2,327,712
Engineering, Procurement & Construction Management:	279,325
Contingency:	349,157
Contractor Overhead/Profit:	349,157
Total Capital:	$3,305,351
Total Project Capital and O & M Cost:	**$3,305,351**

COST ESTIMATE FOR GREY ZONE DREDGING

Capital Items	Quantity	Units	Cost
Dredging			
Mobilization	1	ea	$115,000
Dredging/Offloading/Screening	177,310	cy	$1,070,551
Dredge Monitoring	1	LS	$20,000
Upland Management			
Upland Handling	177,310	cy	886,550
On-Site Recycling	177,310	cy	2,127,720

Direct Capital:	$4,219,821
Engineering, Procurement & Construction Management:	506,379
Contingency:	632,973
Contractor Overhead/Profit:	632,973
Total Capital:	$5,992,146
	-
Total Project Capital and O & M Cost:	**$5,992,146**

COST ESTIMATE FOR GREY ZONE NATURAL RECOVERY

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Natural Recovery Monitoring	10	38,000	254,983

Total Present Worth, Longer Term O & M Costs:	$254,983
Total Project Capital and O & M Cost:	**$254,983**

COST ESTIMATE FOR GREY ZONE ENHANCED NATURAL RECOVERY

Capital Items	Quantity	Units	Cost
Sediment Placement	26,100	cy	146,160

Direct Capital:	$146,160
Engineering, Procurement & Construction Management:	17,539
Contingency:	21,924
Contractor Overhead/Profit:	21,924
Total Capital:	$207,547

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Natural Recovery Monitoring	10	38,000	254,983

Total Present Worth, Longer Term O & M Costs:	$254,983
Total Project Capital and O & M Cost:	**$462,530**

COST ESTIMATE FOR
CONSTRUCT CDF (2.9 acres), DREDGE & PLACE T-DOCK & NEARSHORE

Capital Items	Quantity	Units	Cost
<u>CDF Construction</u>			
Pre-Placement Blanket	2,500	cy	$7,250
Sediment Placement	25,000	cy	$48,333
<u>Dredging</u>			
Mobilization	1	ea	$115,000
Dredging	29,308	cy	$656,499
Place in CDF	29,308	cy	$84,993
Cap CDF	5,000	cy	14,500
Backfill Dredge Area	29,308	cy	$84,993
Dredge Monitoring	1	LS	$20,000
<u>Dewatering</u>			
Water Treatment	2,459,242	gal	19,674
<u>Air Sparging System</u>			
Mobilization	1	LS	$50,000
Air Sparging Wells	40	ea	$400,000
Air Injection Blower, Controls, etc.	1	LS	$68,922

Direct Capital:	$1,570,165
Engineering, Procurement & Construction Management:	188,420
Contingency:	235,525
Contractor Overhead/Profit:	235,525
Total Capital:	$2,229,634

Present Worth of Longer Term Operating Costs	Years	Annual Cost	Cost
Operation and Maintenance	30	94,210	1,060,594

Total Present Worth, Longer Term O & M Costs: $1,060,594

Total Project Capital and O & M Cost: $3,290,228

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COST ESTIMATE FOR
NEARSHORE CONTAINMENT (0.5 acres), DREDGE & TREAT NEARSHORE TOE

Capital Items		Quantity	Units	Cost
Pre-Placement Blanket		2,500	cy	$7,250
Clean Fill Placement		20,000	cy	$38,667
<u>Dredging</u>				
Mobilization		1	ea	$115,000
Dredging		28,288	cy	$633,651
Upland Offloading		28,288	cy	$164,070
Dredge Area Backfill		28,288	cy	$82,035
Dredge Monitoring		1	LS	$20,000
<u>Dewatering</u>				
Water Treatment		2,373,653	gal	18,989
<u>Treatment</u>				
Upland Handling		28,288	cy	$141,440
On-Site Thermal		39,603	ton	1,980,160
	Direct Capital:			$3,201,263
	Engineering, Procurement & Construction Management:			384,152
	Contingency:			480,189
	Contractor Overhead/Profit:			480,189
	Total Capital:			$4,545,793
	Total Project Capital and O & M Cost:			**$4,545,793**

COST ESTIMATE FOR
T-DOCK DREDGING & TREATMENT

Capital Items		Quantity	Units	Cost
<u>Dredging</u>				
Mobilization		1	ea	$115,000
Dredging		21,080	cy	$472,192
Upland Offloading		21,080	cy	$122,264
Dredge Area Backfilling		21,080	cy	$61,132
Dredge Monitoring		1	LS	$20,000
<u>Dewatering</u>				
Water Treatment		1,768,828	gal	14,151
<u>Treatment</u>				
Upland Handling		21,080	cy	$105,400
On-Site Thermal		29,512	ton	1,475,600
	Direct Capital:			$2,385,739
	Engineering, Procurement & Construction Management:			286,289
	Contingency:			357,861
	Contractor Overhead/Profit:			357,861
	Total Capital:			$3,387,749
	Total Project Capital and O & M Cost:			**$3,387,749**

COST ESTIMATE FOR
NEARSHORE DREDGING & TREATMENT (6 ft below mud line)

Capital Items	Quantity	Units	Cost
<u>Dredging</u>			
Mobilization	1	ea	$115,000
Dredging	33,218	cy	$744,083
Upland Offloading	33,218	cy	$192,664
Dredge Area Backfilling	33,218	cy	$96,332
Dredge Monitoring	1	LS	$20,000
<u>Dewatering</u>			
Water Treatment	2,787,331	gal	22,299
<u>Treatment</u>			
Upland Handling	33,218	cy	$166,090
On-Site Thermal	46,505	ton	2,325,260

Direct Capital:	$3,681,728
Engineering, Procurement & Construction Management:	441,807
Contingency:	552,259
Contractor Overhead/Profit:	552,259
Total Capital:	$5,228,054
Total Project Capital and O & M Cost:	**$5,228,054**

COST ESTIMATE FOR
MITIGATION - WETLAND REPLACEMENT

Capital Items	Quantity	Units	Cost
Wetland Replacement	1	LS	$400,000

Direct Capital:	$400,000
Engineering, Procurement & Construction Management:	48,000
Contingency:	60,000
Total Capital:	$508,000
Total Project Capital and O & M Cost:	**$508,000**

COST ESTIMATE FOR
MITIGATION - GYPSY CREEK REALIGNMENT

Capital Items	Quantity	Units	Cost
Gypsy Creek Realignment	1	LS	400,000

Direct Capital:	$400,000
Engineering, Procurement & Construction Management:	48,000
Contingency:	60,000
Total Capital:	$508,000
Total Project Capital and O & M Cost:	**$508,000**

COST ESTIMATE FOR
MITIGATION - FOR CDF (2.9 acres)

Capital Items	Quantity	Units	Cost
2.9 acre Mitigation	1	LS	$400,000

Direct Capital:	$400,000
Engineering, Procurement & Construction Management:	48,000
Contingency:	60,000
Total Capital:	$508,000
Total Project Capital and O & M Cost:	**$508,000**

COST ESTIMATE FOR
MITIGATION - FOR NEARSHORE CONTAINMENT CELL

Capital Items	Quantity	Units	Cost
0.5 acre Mitigation	1	LS	400,000

Direct Capital:	$400,000
Engineering, Procurement & Construction Management:	48,000
Contingency:	60,000
Total Capital:	$508,000
Total Project Capital and O & M Cost:	**$508,000**

COST SUMMARY
B - SEDIMENT REMEDIATION/MITIGATION
PORT QUENDALL DEVELOPMENT

SEDIMENT REMEDIATION	
Mobilization/Site Preparation	$468,600
Remove/Recycle Wood Waste	$3,305,351
Grey Zone Dredging	$5,992,146
Grey Zone Natural Recovery	$254,983
Grey Zone Enhanced Natural Recovery	$462,530
Construct CDF (2.9 acres), Dredge & Place T-Dock and Nearshore	$3,290,228
Nearshore Containment (0.5 acres), Dredge and Treat Nearshore Toe	$4,545,793
T-Dock Dredging & Treatment	$3,387,749
Nearshore Dredging & Treatment (6 ft below mud line)	$5,228,054
MITIGATION	
Wetland Replacement	$508,000
Gypsy Creek Realignment	$508,000
For CDF (2.9 acres)	$508,000
For Nearshore Containment Cell (0.5 acres)	$508,000